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Rio Blanco Oil Shale Project

REVISED DETAILED DEVELOPMENT PLAN TRACT C-a

VOLUME 3

ENVIRONMENTAL PROTECTION and MONITORING

Gulf Oil Corporation – Standard Oil Company (Indiana)

May, 1977

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RIO BLANCO OIL SHALE PROSPECT

REVISED
DETAILED DEVELOPMENT PLAN
TRACT C-a

VOLUME 3

SECTION 6 ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

SECTION 7 ENVIRONMENTAL ASSESSMENT

SECTION 8 ENVIRONMENTAL MONITORING

Submitted To Area Oil Shale Supervisor,
Geological Survey, U.S. Department of the Interior,
Pursuant To Lease No. C-20046

Gulf Oil Corporation – Standard Oil Company (Indiana)

May, 1977

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REVISED DDP ABSTRACT

In 1969, the U. S. Department of the Interior initiated planning for a prototype oil shale leasing program that eventually resulted in Gulf Oil Corporation and Standard Oil Company (Indiana) acquiring an oil shale lease for Tract C-a in the Piceance Creek basin of northwest Colorado. Gulf and Standard submitted the high bonus bid for Tract C-a ($210,305,600) at a lease sale in Denver on January 8, 1974. Rio Blanco Oil Shale Project (RBOSP), an organization directed and staffed by representatives of Gulf and Standard, was formed later that year for the purpose of developing the tract.

RBOSP has conducted extensive geotechnical and environmental data collection programs to establish baseline conditions on and around Tract C-a and to provide input for the selection of mining and processing plans. This revised Detailed Development Plan (DDP) describes RBOSP's proposed development and operation of a commercial-scale oil shale complex and support facilities on and around Tract C-a. The development plan, environmental protection plans and environmental monitoring programs are based on the best technology presently available. Specific details of the engineering and environmental projections will change because of continually improving technology in these areas. RBOSP will be flexible and responsive to changes in information and technology and will incorporate new information into the project plans wherever warranted.

Before RBOSP can proceed with development of Tract C-a, several approvals and permits must be obtained from County, State and Federal governments. Among these are approval of the DDP, and acquisition of necessary rights-of-way and all permits for construction and operations, which presupposes the emissions and effluents from the operation will be acceptable under State and Federal regulations.

PROJECT DESCRIPTION

This revised DDP presents a 40-year plan for developing the oil shale resource on Tract C-a. This includes a 10-year Modular Development

Phase and a 30-year Commercial Phase. At the end of that time, approximately one-half of the tract will have been developed. RBOSP will develop the resources consistent with environmental, technical and economic constraints which prevail now or may exist in the future.

Development will consist of Modified In Situ (MIS) recovery of shale oil, on-tract surface retorting of the material brought to the surface, on-tract disposal of processed shale and waste materials and on-tract support facilities. The MIS method to be used by the Rio Blanco Oil Shale Project employs well known sublevel caving mining methods in combination with technology similar to in situ recovery of heavy oil from sand reservoirs in conventional oil fields. Mining involves the sinking of vertical shafts followed by development of rubblized zones which become underground retorts. The deposit is divided into cells of rubblized oil shale separated by pillars of undisturbed oil shale. Because most retorting occurs underground, the need for large off-tract processing and disposal areas is eliminated. The MIS method is considered by RBOSP as the best technique for achieving a combination of good resource recovery, minimum environmental impact and economic acceptability.

The two phases of the MIS operations include a Modular Development Phase and a Commercial Phase. The Modular Development Phase will consist of underground retorting only and will be conducted near the center of the commercial mine area during the first 10 years of operation (1977-86, including construction). During this time period, a number of retorts will be built and burned in sequence to gain operating experience, improve process efficiency, and confirm capital and operating costs for a commercial operation. The beginning of construction for the Modular Development Phase and all subsequent dates is keyed to timely approval of the DDP and the end of the suspension of operations granted by the Department of the Interior in 1976.

Engineering and construction for the Commercial Phase will begin in 1982 after results of the first prototype commercial-size retort, to be built

in 1981, have been analyzed. Completion of commercial-size retorts and support facilities is anticipated to take up to five years. During this period, single commercial-size prototype retorts will continue to be burned as part of the Modular Development Phase. Table 1 is a summary of information pertinent to RBOSP's proposed development of Tract C-a. Figure 1 depicts the location of proposed facilities.

The Modular Development Phase consists of developing several retorts off the same shaft. Retorts 1 and 2, starting in 1979, will allow evaluation of the retorting model prediction, provide practical field operating experience and supply samples for laboratory and field experiments. Retorts 3 and 4 will test mining concepts and the scaling-up of the size of the retorts. These two retorts will be developed and burned in 1980 and 1981.

Commercial scale operating conditions will be demonstrated in Retort 5 and beyond, with operations beginning in 1981. These retorts are large enough to be developed by the sublevel caving method. Objectives for the remaining prototype commercial retorts are to evaluate commercial-size retorts and continue to optimize both mining and retorting operations while the commercial facilities are under construction.

The shale oil produced in all Modular Development Phase retorts will be pumped to the surface and trucked to a market point. During this phase, a permit will be obtained from the Colorado Department of Health to thermally oxidize the gases before they are vented to the atmosphere. Mined material in the Modular Development Phase will be trucked from the mine and used for fill as required; the balance will be piled and re-vegetated.

Engineering and conceptual design work on the proposed facilities is based on producing 76,000 barrels per stream day (BPSD). This higher production rate resulted from conservative original estimates of component capacity. However, RBOSP intends to demonstrate commercial feasibility and other objectives of the prototype oil shale program at

an initial rate of about 50,000 BPSD. Should future conditions warrant, production could be expanded to 76,000 BPSD.

All environmental assessment was based on 76,000 BPSD production rate. The assessments and models show that RBOSP can satisfy environmental stipulations and regulations at this higher production rate. They can easily be met at the rate of 50,000 BPSD since environmental effects will be reduced in proportion to plant capacity.

Table 1

RIO BLANCO PROJECT SUMMARY

	MODULAR DEVELOPMENT PHASE	COMMERCIAL PHASE
Timing		
Construction	Sept. 1977-Oct. 1979	June 1982-Jan. 1987
Operation	Begin Oct. 1979	Begin Feb. 1987
Mine Development		
Ore Production (Average Brought to Surface)	Retorts 1-5, 500 TPSD Retorts 6 & up, 3000 TPSD	40,000 TPSD
Ore Rubblized (In Situ)	Up to 12,000 TPSD	134,000 TPSD
Ore Haulage (Surface)	Truck	Belt Conveyors
Processing		
Retorting-Surface	-	TOSCO II
Retorting-Underground	Modified In Situ	Modified In Situ
Processed Shale Haulage	-	Belt Conveyors
Products		
Shale Oil	Up to 4000 BPSD	76,000 BPSD
Sulfur	-	265 LTPSD
Product Movement	Truck (Shale Oil)	Pipeline (Shale Oil) Truck (Sulfur)
Net Groundwater Used	Up to 1000 AFY	2200 AFY
Power (Purchased)	Up to 40 MW	100 MW
Peak Employment	2500 for 76,000 BPSD 1900 for 50,000 BPSD	2075 for 76,000 BPSD 1550 for 50,000 BPSD

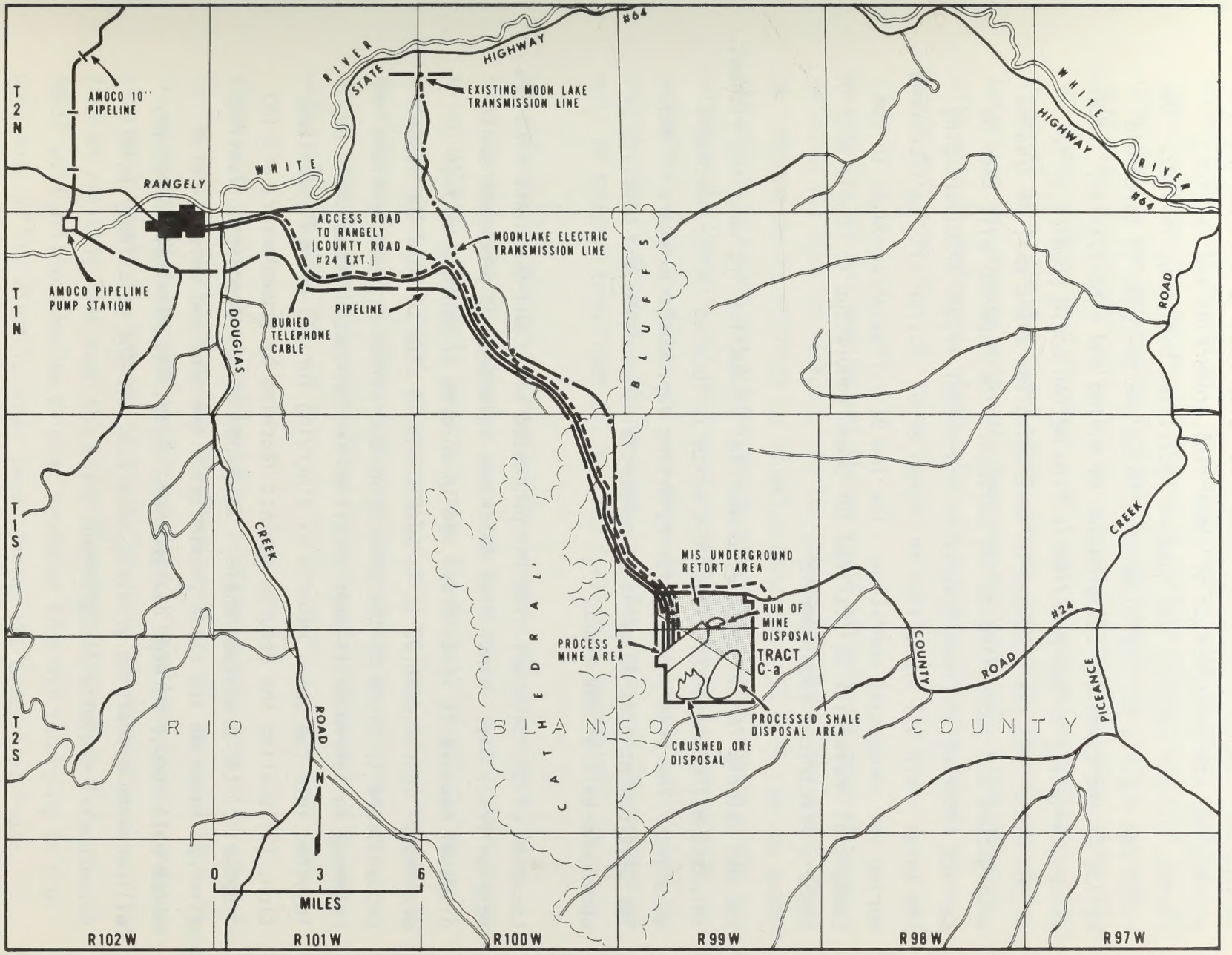


Figure 1

LOCATION OF RBOSP FACILITIES

Information learned from early commercial-size retorts will be used for engineering and construction of commercial production and service shafts, surface retorts, and support facilities beginning in 1982. The rubblized retorts for the Commercial Phase are designed to have void ratios of approximately 20% produced by mining and rubblization. Underground retorting by the Modified In Situ method could produce up to 57,000 BPSD. The ore produced in developing the voids will be crushed underground and stockpiled on the surface. The material will then be surface retorted to produce up to an additional 19,000 BPSD, bringing the total shale oil production to 76,000 BPSD. Sulfur will be recovered during the commercial operation. The low BTU offgases produced in the Commercial Phase will be utilized for power generation to supply most of RBOSP's electrical requirements.

The MIS retorts for 30 years of commercial production includes the richest, thickest oil shale within Tract C-a which is located in the northeast quadrant. The area proposed for retorting represents 10 years of modular development plus 30 years of commercial production and consists of about one-half of the tract.

Location of the disposal site for processed shale and the plant site are both on Tract C-a. Rinky Dink Gulch was selected for processed shale disposal because it is on tract and in an area of minimum surface drainage. Operationally, it is sufficient in size to hold the waste products and is close to the processing operations. Investigations are underway to determine if part or all of the processed shale could be injected into the spent retorts by slurrying for (1) ground stabilization, (2) sealing the retorts against leaching by groundwater, and (3) disposal of the processed shale. Selection of the processing facility site was based on its close proximity to the mine and disposal area which will reduce acreage disturbance. Also, the elevated topography will enhance dispersion of stack emissions and the relatively level terrain will minimize disturbance.

During the Modular Development Phase, the ore removed to create the 20% underground void volume will be transported to the disposal area by truck. During the Commercial Phase, it will be transported from the MIS mine area to the processing facility by belt conveyor. After surface retorting, processed shale will be transported to the disposal area from the plant site by belt conveyor. As final slopes are established on the disposal pile, the processed shale will be covered by coarse, crushed materials and covered with soil from the disposal areas. The disposal pile will be contoured, revegetated and progressively reclaimed as operations proceed.

During the Modular Development Phase, shale oil will be trucked to an existing refinery or markets. In the Commercial Phase, shale oil will be transported by pipeline to Rangely, Colorado. It will then be pumped through an existing Amoco pipeline to other connecting carriers for ultimate delivery to refineries or markets in the West or Midwest. If necessary, flow improvers will be added to the raw shale oil to make it a pipelineable product. The by-product sulfur recovered from retorting will be trucked from Tract C-a to rail facilities near Rifle, Colorado.

Mine dewatering during the Modular Development and Commercial Phases will produce more water than is required for project needs. This excess water will be reinjected off-tract into the basin's aquifers. Up to 1000 acre-feet/year (AFY) of groundwater will be used during the Modular Development Phase, obtained from mine seepage and/or the dewatering wells. During the Commercial Phase, approximately 2200 AFY of groundwater will be used.

RBOSP will require the purchase of up to 40 megawatts (MW) of electricity during the Modular Development Phase operations. The demand will increase to about 100 MW during the Commercial Phase. Moon Lake Electric Association will supply electricity to Tract C-a via a 138 KV transmission line from an existing line near the White River 20 miles north of the tract. RBOSP will utilize the low BTU gas produced from MIS retorting to produce most of its electric power needs during the Commercial Phase.

Mountain Bell Telephone Company will provide communications from Rangely for commercial construction and operations. Vehicular access to Tract C-a will be via Rio Blanco County Road 24 (Ryan Gulch Road) from the east and via an extension of this road from the tract to Rangely on the west. The power transmission line, shale oil pipeline, and access road will be located, wherever possible, in a common corridor between Rangely and Tract C-a in accordance with the present Bureau of Land Management corridor concepts.

BASELINE ENVIRONMENTAL AND GEOTECHNICAL CONDITIONS

Collection of baseline environmental data on and around Tract C-a began in October, 1974. Since individual tasks started at various times, two full years of collection in some categories were not completed until early February, 1977. The program was designed to gather extensive environmental data for the purposes of (1) complying with lease stipulations to describe baseline environmental conditions prior to development and, (2) developing a scientifically sound environmental data base to help in the design of an environmentally acceptable DDP. During planning and development of the baseline programs, environmental lease stipulations were subjected to critical review. Potential data gaps inherent in the stipulations were identified and suggestions for amendments to the lease were made.

After thorough evaluation and study, a final scope of work was submitted to and approved by the Area Oil Shale Supervisor (AOSS) following review and recommendation by the Oil Shale Environmental Advisory Panel.

Programs were developed to study several areas of environmental concern including meteorology and air quality, and terrestrial and aquatic ecology. The programs were also designed to describe interrelationships among components of the ecosystem and identify areas of cultural resources. The environmental baseline conditions and analyses upon which the DDP environmental information is based were submitted as a separate report to the AOSS in May, 1977 entitled "Final Environmental Baseline Report for Tract C-a and Vicinity."

Geotechnical data gathering, including geologic and hydrologic resource evaluation through core hole drilling and geophysical logging, began in July of 1974. The geologic program conducted by RBOSP provides detailed structural, stratigraphic and resource data.

The hydrologic program conducted by RBOSP provides the data for determining the hydrologic environmental baseline, aquifer characteristics, and quality and quantity of water expected to be produced from various mining plans.

ENVIRONMENTAL PROTECTION

RBOSP's plan is to construct and operate an environmentally acceptable oil shale operation. Specific environmental protection procedures have been developed to ensure compliance with lease provisions and with all applicable Federal, State and local environmental protection and pollution control regulations. The procedures and mitigation plans are designed specifically for RBOSP's intended development of Tract C-a and will be modified as necessary with changing conditions. The protection procedures described in the development plan cover the following topics:

- Health and Safety
- Air Quality Control
- Water Quality Control
- Solid Waste Control
- Noise Control
- Aesthetics
- Abandonment
- Fish and Wildlife Management
- Land Rehabilitation
- Oil and Hazardous Materials Control
- Fire Prevention and Control
- Protection of Objects of Historic and Scientific Interest
- Subsidence Control

RBOSP's assessment of potential environmental impacts which could result from Tract C-a activities include studies of air and water quality, terrestrial and aquatic biology, and cultural resources. Assessments were based on emissions, dispersion modeling and tracer studies, water flow modeling, and in-depth analyses of environmental baseline.

Environmental monitoring programs have been designed to provide data which will identify impacts to the environment resulting from development activities. Changes from conditions existing prior to development as established by the baseline data collection program will be recorded. These programs will allow evaluation of the success of the mitigation plans. Should the monitoring programs show that the control plans are not working as predicted, the control plans will be modified to enhance their effectiveness.

A monitoring program has been initiated since the baseline programs were completed on Tract C-a. Monitoring will continue, as the lease requires, until the Area Oil Shale Supervisor determines to his satisfaction that environmental conditions consistent with Federal and State statutes and regulations have been established.

SOCIAL AND ECONOMIC PLANNING

Gulf and Standard began working with the people of northwestern Colorado shortly after acquiring the Tract C-a lease in 1974. Recognizing the importance of dealing with the potential social and economic impacts of oil shale development, the companies participated in planning with local, County, State and Federal governmental agencies.

Although a social and economic impact statement was not required by the Tract C-a lease, RBOSP officials and the Area Oil Shale Supervisor felt such a plan was desirable. Therefore, the Social and Economic Impact Statement for Tract C-a was submitted as a separate document along with the Detailed Development Plan. An addendum which updates the statement was submitted with the revised DDP.

The overall objective of the plan is to reduce negative impacts which have occurred in other areas because of industrial activity. In addition to the Social and Economic Impact Statement, Gulf and Standard sponsored the preparation of a master plan for the town of Rangely, Colorado, which has been adopted by the community and has been certified by Rio Blanco County.

DDP ORGANIZATION AND USE

RBOSP's DDP consists of 8 sections comprising 3 volumes, as depicted in the chart on page 12. Volume 1 is the "Executive Summary". If one is interested in an overview of the development plan, Volume 1 is recommended.

Volume 2 describes engineering plans for developing Tract C-a and includes sections on mining, processing, processed shale disposal and support facilities. Volume 3 describes RBOSP's environmental protection plans and also includes sections concerning environmental assessment and monitoring. The Confidential Volume, which is not publicly available, contains proprietary information concerning oil shale properties, ore reserves and cost estimates.

Except for this DDP abstract, a 3-number page numbering system is used throughout the development plan. Any given page number is unique in that it is not repeated elsewhere in the DDP. Page numbers are keyed to chapters within sections; page 2-6-15, for example, refers to Section 2, Chapter 6, page 15.

RIO BLANCO OIL SHALE PROJECT
MIS-DETAILED DEVELOPMENT PLAN ORGANIZATION

VOLUME 1

INTRODUCTION AND EXECUTIVE SUMMARY

— SECTION 1 —

CHAPTER

1 PROJECT BACKGROUND AND OVERVIEW
2 MINING
3 PROCESSING
4 PROCESSED SHALE AND DEVELOPMENT ORE DISPOSAL
5 SUPPORT FACILITIES
6 ENVIRONMENTAL PROTECTION, HEALTH & SAFETY
7 ENVIRONMENTAL ASSESSMENT
8 ENVIRONMENTAL MONITORING

VOLUME 2

MINING, PROCESSING AND SUPPORT FACILITIES

— SECTION 2 —

MINING

CHAPTER

1 INTRODUCTION
2 SITE DESCRIPTION
3 GEOLOGY
4 HYDROLOGY
5 ROCK MECHANICS
6 MINE DESIGN
7 SCHEDULES
8 SUBSIDENCE
9 MINING ALTERNATIVES AND SELECTION

— SECTION 3 —

PROCESSING

CHAPTER

1 INTRODUCTION
2 MODULAR DEVELOPMENT PHASE PROCESSING OPERATIONS
3 COMMERCIAL PHASE PROCESSING OPERATIONS
4 PLOT PLAN
5 COMMERCIAL PHASE PROCESSING ALTERNATES
6 MODULAR DEVELOPMENT PHASE PROCESSING ALTERNATES

— SECTION 4 —

PROCESSED SHALE & DEVELOPMENT ORE DISPOSAL

CHAPTER

1 INTRODUCTION
2 PROCESSED SHALE DISPOSAL OPERATION
3 DEVELOPMENT ORE DISPOSAL OPERATION

— SECTION 5 —

SUPPORT FACILITIES

CHAPTER

1 INTRODUCTION
2 TRANSPORTATION
3 POWER SUPPLY AND DISTRIBUTION
4 PRODUCT PIPELINE
5 WATER MANAGEMENT
6 COMMUNICATIONS
7 FUEL STORAGE AND HANDLING
8 BUILDINGS
9 EXPLOSIVE STORAGE AND HANDLING

VOLUME 3

ENVIRONMENTAL PROTECTION & MONITORING

— SECTION 6 —

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER

1 INTRODUCTION
2 HEALTH AND SAFETY
3 FIRE PREVENTION AND CONTROL
4 NOISE CONTROL
5 AIR QUALITY CONTROL
6 WATER QUALITY CONTROL
7 OIL AND HAZARDOUS MATERIAL CONTROL
8 LAND REHABILITATION AND EROSION CONTROL
9 SOLID WASTE CONTROL
10 AESTHETICS
11 FISH AND WILDLIFE MANAGEMENT PLAN
12 PROTECTION OF OBJECTS OF SCIENTIFIC AND HISTORIC INTEREST
13 SUBSIDENCE CONTROL
14 ABANDONMENT

— SECTION 7 —

ENVIRONMENTAL ASSESSMENT

CHAPTER

1 INTRODUCTION
2 ENVIRONMENTAL SETTING AND WILDLIFE INVENTORY
3 AIR
4 ASSESSMENT AND MITIGATION OF POTENTIAL TERRESTRIAL IMPACTS
5 ASSESSMENT AND MITIGATION OF POTENTIAL AQUATIC IMPACTS
6 ASSESSMENT AND MITIGATION OF HYDROLOGY IMPACTS
7 ASSESSMENT AND MITIGATION OF IMPACTS ON CULTURAL RESOURCES

— SECTION 8 —

ENVIRONMENTAL MONITORING

CHAPTER

1 INTRODUCTION
2 AIR QUALITY
3 METEOROLOGY
4 TERRESTRIAL ECOLOGY
5 AQUATIC ECOLOGY
6 HYDROLOGY
7 REVEGETATION
8 SUBSIDENCE
9 NOISE

VOLUME 4

CONFIDENTIAL VOLUME

CONTENTS

VOLUME 3

ENVIRONMENTAL PROTECTION AND MONITORING

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 1 INTRODUCTION

CHAPTER 2 HEALTH AND SAFETY

2.1 Applicable Regulations. 6-2-1

2.2 Personnel Responsibilities. 6-2-2

2.3 Safety and Accident Prevention Program. 6-2-3

2.4 Reports and Logs. 6-2-5

2.5 Special Concerns. 6-2-5
A. Airborne Contaminants. 6-2-6
B. Noise Control. 6-2-7
C. Explosives 6-2-7
1. Definition of Explosives. 6-2-7
2. Classes of Explosives 6-2-7
3. Storage Facilities for Explosives 6-2-7
4. Transport of Explosives 6-2-8
5. Use of Explosives 6-2-9
D. Electrical Facilities. 6-2-10
1. Cables and Power Lines. 6-2-10
2. Grounding 6-2-11
3. Lightning Protection. 6-2-11
4. Electrical Equipment. 6-2-11
E. Machinery and Equipment. 6-2-12
F. First Aid and Medical Facilities 6-2-12
G. Health and Sanitation. 6-2-13
H. Signs and Posters. 6-2-14
I. Personal Protective and Life-Saving Equipment. . . . 6-2-14
J. Protection of the Public 6-2-14
K. Toxicology Studies 6-2-15

CHAPTER 3 FIRE PREVENTION AND CONTROL

3.1 Applicable Regulations. 6-3-1

3.2 Construction. 6-3-2
A. Tools and Equipment. 6-3-2
B. Special Precautions. 6-3-3
C. Open Burning 6-3-4

3.3 Mining. 6-3-5

3.4 Processing Facility 6-3-6
A. Plant Design and Layout. 6-3-7
1. Process Units 6-3-7
2. Storage Facilities. 6-3-9
B. Plant Inspections. 6-3-10
C. Fire Protection Equipment. 6-3-11
D. Fire Protection Water System 6-3-11
E. Major Equipment. 6-3-12
F. Communication System 6-3-13

3.5 Mobile Equipment. 6-3-14

3.6 Stockpiles. 6-3-15

3.7 Crushers, Conveyors and Baghouses 6-3-15

3.8 Offices, Warehouses and Shops 6-3-15

3.9 Fuel Storage and Dispensing 6-3-16

3.10 Welding and Cutting Operations. 6-3-16

3.11 Management and Training 6-3-17
A. Training 6-3-17
B. Emergency Procedures 6-3-18

CHAPTER 4 NOISE CONTROL

4.1 Regulations 6-4-1

4.2 Noise Levels. 6-4-1

4.3 Control Methods 6-4-3

4.4 Noise Monitoring. 6-4-4

CHAPTER 5 AIR QUALITY CONTROL

5.1 Construction. 6-5-1
A. Roads. 6-5-1
B. Mine Site. 6-5-2
C. Processing Facility. 6-5-2
D. Processed Shale Disposal Area. 6-5-3
E. Development Ore Disposal Piles and Soil Stockpiles . 6-5-3
F. Support Facilities 6-5-3
G. Burning Control. 6-5-4
H. Construction Vehicles and Equipment. 6-5-4

5.2 Mining. 6-5-4
A. Modular Development Phase. 6-5-4
B. Commercial Phase 6-5-6

5.3 Development Ore Handling. 6-5-6
A. Modular Development Phase. 6-5-6
1. Dust Suppression System 6-5-6
2. Vehicular Dust Control. 6-5-6
3. Ore Disposal Dust Control 6-5-7
B. Commercial Phase 6-5-7
1. Ore Handling Dust Control 6-5-8
2. Crushed Development Ore Disposal Dust Control 6-5-8

5.4 Retort Feedstock Preparation. 6-5-9
A. Stockpiling of Primary Crushed Ore 6-5-9
B. Reclaiming from Primary Crushed Ore Stockpile. . . . 6-5-11
C. Secondary Crushing and Screening 6-5-11
D. Feedstock Storage. 6-5-12
E. Alternative Dust Control Techniques. 6-5-12
F. Table of Estimated Feedstock Preparation Particulate Emissions 6-5-12

5.5 Processing. 6-5-13
A. Modular Development Phase. 6-5-14
1. Plant Design. 6-5-14
2. Operation and Maintenance 6-5-14
B. Commercial Phase 6-5-16
1. Plant Design. 6-5-16
2. Operation and Maintenance 6-5-19

5.6 Processed Shale Disposal and Support Facilities 6-5-19
A. Processed Shale Dust Control 6-5-21
B. Disposal Pile Fugitive Dust Control. 6-5-22
C. Support Facilities 6-5-22

5.7 Modeling. 6-5-23
A. Dispersion Modeling. 6-5-23
1. Dispersion Meteorology Summary. 6-5-23
2. Air Quality Standards and Classifications . . . 6-5-36
a. Colorado State Standards 6-5-36
b. Federal Standards. 6-5-37
1) National Ambient Air Quality Standards (NAAQS) 6-5-37
2) Significant Deterioration Regulations 6-5-38
3. Source Emission Inventory 6-5-38
4. Modeling Methodology. 6-5-42
a. Long-Term Interval Modeling (CRSTER) . . . 6-5-42
b. Short-Term Interval Modeling 6-5-46
5. Modeling Results. 6-5-48
a. Modular Development Phase. 6-5-50
1) Sulfur Dioxide. 6-5-52
2) Nitrogen Dioxide. 6-5-58
3) Particulates. 6-5-58
4) Non-Methane Hydrocarbons. 6-5-65

b. Commercial Phase Operations. 6-5-65
1) Sulfur Dioxide. 6-5-65
2) Nitrogen Dioxide. 6-5-69
3) Particulates. 6-5-69
4) Non-Methane Hydrocarbons. 6-5-77
c. Fumigation Modeling. 6-5-77
d. Fugitive Particulate Emissions and Air Quality Impact 6-5-82
e. Mine Ventilation Emissions and Associated Air Quality Impact 6-5-90
B. Salt Drift From Cooling Tower. 6-5-91

5.8 Applicable Regulations. 6-5-97
A. Tract C-a Shale Lease. 6-5-97
B. National Environmental Policy Act of 1969 and the Environmental Protection Agency 6-5-97
C. Occupational Safety and Health Act of 1970 6-5-97
D. Mining Enforcement and Safety Administration (MESA). 6-5-98
E. State of Colorado Air Pollution Control Act of 1970 6-5-98
F. Colorado Mining Laws with Safety and Health Regulations 6-5-98
G. Colorado Department of Labor and Colorado Occupational Safety and Health (COSH) 6-5-98

5.9 Definitions 6-5-99

CHAPTER 6 WATER QUALITY CONTROL

6.1 Zero Discharge Water Handling 6-6-3

6.2 Modular Development Phase 6-6-3
A. Water Flow 6-6-5
B. Dewatering and Reinjection 6-6-5
C. Evaporation and Dust Control 6-6-7
D. Potable Water. 6-6-7
E. Processing Facility. 6-6-7
F. Surface Runoff, Diversion and Retention. 6-6-7
G. Fire Protection Water. 6-6-9
H. Sanitary Sewage Treatment Facilities 6-6-9

6.3 Commercial Phase. 6-6-9
A. Water Flow 6-6-10
B. Dewatering and Reinjection 6-6-10
C. Evaporation and Dust Control 6-6-10
D. Processed Shale Disposal Pile. 6-6-12
E. Potable Water. 6-6-12
F. Processing Facilities. 6-6-12
G. Surface Runoff, Diversion and Retention. 6-6-13
H. Fire Protection Water. 6-6-14
I. Sanitary Sewage Treatment Facilities 6-6-14

6.4 Summary 6-6-14

CHAPTER 7 OIL AND HAZARDOUS MATERIAL CONTROL

7.1 Applicable Regulations. 6-7-1

7.2 Storage and Handling. 6-7-2
A. Storage. 6-7-2
B. Handling of Pesticides 6-7-3

7.3 Spill Contingency 6-7-3
A. Nontransportation - Related Facilities 6-7-5
1. Discovery and System Shutdown 6-7-5
2. Notification. 6-7-5
a. Reporting to Federal and State Agencies. . 6-7-5
b. Internal Reporting 6-7-5
3. Information Gathering 6-7-6
4. Manpower, Equipment and Material Availability . 6-7-6
5. Containment 6-7-6
6. Removal 6-7-7
7. Cleanup and Restoration 6-7-7
B. Transportation - Related Facilities. 6-7-7
1. Responsibility and Notification 6-7-8
2. Locate and Identify Source of Discharge 6-7-12
3. Stop Discharge. 6-7-13
4. Contain Spill 6-7-13
5. Evaluate and Cope with Hazards. 6-7-14
6. Repair and Cleanup. 6-7-14
7. Evaluate and Complete Reports 6-7-14
C. Contingency Plan for MIS Underground Pump Room . . . 6-7-14
1. Design Guidelines 6-7-15
2. Operating Guidelines. 6-7-15
3. Spill Response Guidelines 6-7-15

CHAPTER 8 LAND REHABILITATION AND EROSION CONTROL

8.1 Area Affected 6-8-1

8.2 Site Preparation. 6-8-1
A. Soil Conservation. 6-8-3
B. Artificial Soil Profile. 6-8-3

8.3 Erosion Control 6-8-6
A. Material Size and Classification 6-8-6
B. Slope and Surface Treatment. 6-8-7
C. Drainage 6-8-8
D. Temporary Measures 6-8-8
1. Cover Material. 6-8-8
2. Cover Criteria. 6-8-9

8.4 Revegetation. 6-8-11
A. Introduction 6-8-11
B. Revegetation Technology. 6-8-12

1. Schedule. 6-8-14
2. Seedbed Preparation 6-8-14
3. Seeding 6-8-16
4. Mulches 6-8-19
5. Fertilizers 6-8-21
6. Irrigation. 6-8-21
7. Biotic Influences and Interactions. 6-8-22
8. Management. 6-8-22
9. Summary and Conclusion. 6-8-23
C. RBOSP Experimental Revegetation Program. 6-8-23
1. Revegetation Experiments Initiated in 1975. . . 6-8-24
a. Objectives 6-8-24
b. Methods. 6-8-24
c. Results. 6-8-30
2. Revegetation Experiments Initiated in 1976. . . 6-8-30
a. Objectives 6-8-30
b. Methods. 6-8-32
3. Summary and Conclusion. 6-8-35

CHAPTER 9 SOLID WASTE CONTROL

9.1 Nonprocess Wastes 6-9-1
A. Composition and Quantity 6-9-1
B. Collection and Transport 6-9-2
C. Disposal 6-9-2

9.2 Process Wastes. 6-9-3
A. Modular Development Phase. 6-9-3
B. Commercial Phase 6-9-3

CHAPTER 10 AESTHETICS

10.1 Location. 6-10-1

10.2 Materials and Color 6-10-3

10.3 Shape 6-10-3

10.4 Vegetation. 6-10-3

10.5 Clearing. 6-10-7

10.6 Signs 6-10-7

CHAPTER 11 FISH AND WILDLIFE MANAGEMENT PLAN

11.1 Introduction. 6-11-1

11.2 Wildlife Habitat Modification and Restoration 6-11-9
A. Modification and/or Conversion of Existing Habitat . 6-11-9
1. Habitat Conversion. 6-11-11
2. Habitat Modification. 6-11-13

3. Recommendations 6-11-13
4. Anticipated Results 6-11-15
B. Construction and/or Retention of Structural Habitat. 6-11-16
C. Modifying and/or Increasing Water Availability . . . 6-11-16
D. Restoration of Habitat 6-11-17

11.3 Human Disturbance Control 6-11-19

11.4 Monitoring Program. 6-11-21
A. Terrestrial. 6-11-22
1. Parameter 1 - Range Productivity and Utilization 6-11-22
a. Objectives and Rationale 6-11-22
b. Hypotheses 6-11-22
c. Methods. 6-11-22
d. Experimental Design and Data Analyses. . . 6-11-24
2. Parameter 2 - Browse Utilization. 6-11-24
a. Objectives and Rationale 6-11-24
b. Hypotheses 6-11-25
c. Methods. 6-11-25
d. Experimental Design and Data Analyses. . . 6-11-26
3. Parameter 3 - Species Composition and Percent Cover 6-11-26
a. Objectives and Rationale 6-11-26
b. Hypothesis 6-11-26
c. Methods. 6-11-26
d. Experimental Design and Data Analysis. . . 6-11-26
4. Parameter 4 - Small Mammal Abundance. 6-11-27
a. Objectives and Rationale 6-11-27
b. Hypothesis 6-11-27
c. Methods. 6-11-27
d. Experimental Design and Data Analyses. . . 6-11-28
5. Parameter 5 - Avifauna. 6-11-28
a. Objectives and Rationale 6-11-28
b. Hypothesis 6-11-29
c. Methods. 6-11-29
d. Experimental Design and Data Analysis. . . 6-11-29
B. Aquatic. 6-11-30

11.5 Implementation. 6-11-30

CHAPTER 12 PROTECTION OF OBJECTS OF HISTORIC AND SCIENTIFIC INTEREST

12.1 Cultural Resources Regulations. 6-12-1

12.2 Determination of Significance 6-12-3

12.3 Measures to Avoid Adverse Effects 6-12-3

12.4 Implementation of Mitigation Measures 6-12-5
A. Development, Planning and Scheduling 6-12-5
B. Equipment Operator Training. 6-12-6

CHAPTER 13 SUBSIDENCE CONTROL

13.1 Subsidence Control. 6-13-1

13.2 Subsidence Monitoring 6-13-2

13.3 Subsidence Mitigation 6-13-3

CHAPTER 14 ABANDONMENT

14.1 Mine and Underground Retorts. 6-14-2
A. Modular Development Phase (MDP). 6-14-2
B. Commercial Phase 6-14-3

14.2 Processing Facility 6-14-4

14.3 Processed Shale and Development Ore Disposal Sites. . . . 6-14-5

14.4 Support Facilities. 6-14-5

LITERATURE CITED

SECTION 7

ENVIRONMENTAL ASSESSMENT

CHAPTER 1 INTRODUCTION

CHAPTER 2 ENVIRONMENTAL SETTING AND WILDLIFE INVENTORY

2.1 Topography and Ecology. 7-2-1
A. General Location of Project Area 7-2-1
B. Topography and Cultural Features 7-2-4
C. Geology. 7-2-6
1. Stratigraphy. 7-2-6
2. Structure 7-2-11
3. Overburden. 7-2-13

2.2 Land Use. 7-2-13

2.3 Surface and Subsurface Hydrology. 7-2-17

2.4 Climate and Air Quality 7-2-23

2.5 Terrestrial Ecology 7-2-27

A. Vegetation 7-2-28
B. Small Mammals. 7-2-32
C. Big Game 7-2-34
D. Predatory Mammals. 7-2-36
E. Avifauna 7-2-36
F. Reptiles and Amphibians. 7-2-39
G. Invertebrates. 7-2-39
H. Feral Horses 7-2-40
I. Domestic Livestock 7-2-40
J. Threatened and Endangered Species. 7-2-42

2.6 Aquatic Ecology 7-2-43

2.7 Cultural Resources. 7-2-47

CHAPTER 3 AIR

CHAPTER 4 TERRESTRIAL ASSESSMENT

4.1 Modular Development Phase 7-4-2
A. Construction Impacts 7-4-2
1. Source. 7-4-2
2. Mitigation Measures 7-4-2
3. Impact Assessment 7-4-2
B. Mining Impacts 7-4-4
1. Source. 7-4-4
2. Mitigation Measures 7-4-4
3. Impact Assessment 7-4-5
C. Operational Impacts. 7-4-5
1. Source. 7-4-5
2. Mitigation Measures 7-4-5
3. Impact Assessment 7-4-5
D. Storage and Transfer Impacts 7-4-6
1. Source. 7-4-6
2. Mitigation Measures 7-4-6
3. Impact Assessment 7-4-6
E. Disposal Impacts 7-4-6
1. Source. 7-4-6
2. Mitigation Measures 7-4-7
3. Impact Assessment 7-4-7
F. Manpower Impacts 7-4-8
1. Source. 7-4-8
2. Mitigation Measures 7-4-8
3. Impact Assessment 7-4-9
G. Subsidence 7-4-9
1. Source. 7-4-9
2. Mitigation Measures 7-4-9
3. Impact Assessment 7-4-10
H. Environmental Actions. 7-4-10
1. Source. 7-4-10
2. Mitigation Measures 7-4-10
3. Impact Assessment 7-4-10

4.2 Commercial Phase. 7-4-11
A. Construction Impacts 7-4-11
1. Source. 7-4-11
2. Mitigation Measures 7-4-11
3. Impact Assessment 7-4-12
B. Mining Impacts 7-4-13
1. Source. 7-4-13
2. Mitigation Measures 7-4-13
3. Impact Assessment 7-4-13
C. Operational Impacts. 7-4-14
1. Source. 7-4-14
2. Mitigation Measures 7-4-14
3. Impact Assessment 7-4-14
D. Storage and Transfer Impacts 7-4-19
1. Source. 7-4-19
2. Mitigation Measures 7-4-20
3. Impact Assessment 7-4-20
E. Disposal Impacts 7-4-21
1. Source. 7-4-21
2. Mitigation Measures 7-4-21
3. Impact Assessments. 7-4-22
F. Manpower Impacts 7-4-24
1. Source. 7-4-24
2. Mitigation Measures 7-4-24
3. Impact Assessment 7-4-25
G. Subsidence Impacts 7-4-25
1. Source. 7-4-25
2. Mitigation Measures 7-4-25
3. Impact Assessment 7-4-25
H. Environmental Action Impacts 7-4-26
1. Source. 7-4-26
2. Mitigation Measures 7-4-26
3. Impact Assessment 7-4-26

CHAPTER 5 ASSESSMENT AND MITIGATION OF POTENTIAL AQUATIC IMPACTS

5.1 Modular Development Phase 7-5-1
A. Construction Impacts 7-5-1
B. Mining Impacts 7-5-2
C. Processing Impacts 7-5-4
D. Storage and Transfer Impacts 7-5-4
E. Disposal Impacts 7-5-4

5.2 Commercial Phase. 7-5-5
A. Construction Impacts 7-5-5
B. Mining Impacts 7-5-5
C. Processing Impacts 7-5-7
D. Power Generation Impacts 7-5-7
E. Storage and Transfer Impacts 7-5-7
F. Disposal Impacts 7-5-7
G. Subsidence Impacts 7-5-8
H. Environmental Action Impacts 7-5-9
I. Manpower Impacts 7-5-9

CHAPTER 6 ASSESSMENT AND MITIGATION OF HYDROLOGY IMPACTS

6.1 Modular Development 7-6-1
A. Sources of Impact. 7-6-1
1. Mining. 7-6-1
2. Processing. 7-6-2
3. MIS Retorted Shale. 7-6-2
4. Support Facilities. 7-6-2
B. Mitigation. 7-6-2
C. Impacts. 7-6-3

6.2 Commercial Development. 7-6-4

CHAPTER 7 ASSESSMENT AND MITIGATION OF IMPACTS ON CULTURAL RESOURCES

7.1 Modular Development Phase 7-7-4

7.2 Commercial Development Phase. 7-7-5

LITERATURE CITED

SECTION 8

ENVIRONMENTAL MONITORING

CHAPTER 1 INTRODUCTION

CHAPTER 2 AIR QUALITY

2.1 Ambient Monitoring. 8-2-1
A. Objectives 8-2-1
B. Parameters to be Monitored 8-2-2
C. Monitoring Sites 8-2-4
D. Monitoring Frequency 8-2-5

2.2 Source Emission Monitoring. 8-2-7

CHAPTER 3 METEOROLOGY

3.1 Meteorological Monitoring 8-3-1
A. Meteorological Monitoring Sites. 8-3-2
B. Identification of Parameters to be Monitored 8-3-4
C. Objectives and Rationale 8-3-4
D. Meteorological Data Uses 8-3-5
E. Meteorological Data Analysis 8-3-5

CHAPTER 4 TERRESTRIAL ECOLOGY

4.1 Abiotic Monitoring. 8-4-1
A. Soils. 8-4-1

1. Parameter 1 - Trace Metals. 8-4-1
a. Objectives and Rationale 8-4-1
b. Hypotheses 8-4-3
c. Methods. 8-4-3
d. Experimental Design and Data Analyses. . . 8-4-5
2. Parameter 2 - Soil Conductivity Studies for Salt Drift 8-4-5
a. Objectives and Rationale 8-4-5
b. Hypotheses 8-4-5
c. Methods. 8-4-5
d. Experimental Design and Data Analyses. . . 8-4-7
B. Air Quality. 8-4-7
C. Meteorology. 8-4-7

4.2 Biotic Monitoring 8-4-7
A. Vegetation 8-4-7
1. Parameter 1 - Vegetation Type Distribution. . . 8-4-7
a. Objectives and Rationale 8-4-7
b. Hypothesis 8-4-7
c. Methods. 8-4-7
d. Experimental Design and Data Analyses. . . 8-4-7
2. Parameter 2 - Range Productivity and Utilization. 8-4-8
a. Objectives and Rationale 8-4-8
b. Hypotheses 8-4-8
c. Methods. 8-4-8
d. Experimental Design and Data Analyses. . . 8-4-11
3. Parameter 3 - Browse Condition and Utilization. 8-4-11
a. Objectives and Rationale 8-4-11
b. Hypotheses 8-4-11
c. Methods. 8-4-12
d. Experimental Design and Data Analyses. . . 8-4-12
B. Fauna. 8-4-12
1. Parameter 1 - Small Mammal Abundance. 8-4-14
a. Objectives and Rationale 8-4-14
b. Hypothesis 8-4-14
c. Methods. 8-4-14
d. Experimental Design and Data Analyses. . . 8-4-15
2. Parameter 2 - Avifauna. 8-4-15
a. Objectives and Rationale 8-4-15
b. Hypothesis 8-4-16
c. Methods. 8-4-16
d. Experimental Design and Data Analysis. . . 8-4-17
3. Parameter 3 - Mule Deer Density 8-4-17
a. Objectives and Rationale 8-4-17
b. Hypotheses 8-4-18
c. Methods. 8-4-18
d. Experimental Design and Data Analysis. . . 8-4-19
4. Parameter 4 - Feral Horse Abundance 8-4-20
a. Objectives and Rationale 8-4-20
b. Hypotheses 8-4-20

c. Methods. 8-4-20
d. Experimental Design and Data Analyses. . . 8-4-20
5. Parameter 5 - Rabbit Abundance. 8-4-21
a. Objectives and Rationale 8-4-21
b. Hypothesis 8-4-21
c. Methods. 8-4-21
d. Experimental Design and Data Analyses. . . 8-4-21

CHAPTER 5 AQUATIC ECOLOGY

5.1 Aquatic Studies Design. 8-5-1

5.2 Abiotic Monitoring. 8-5-4
A. Physical Measurements. 8-5-4
1. Objectives. 8-5-4
2. Methods 8-5-4
3. Rationale 8-5-4
4. Data Analysis 8-5-5
B. Water Quality. 8-5-5
1. Objectives. 8-5-5
2. Methods 8-5-5
3. Rationale 8-5-5
4. Data Analysis 8-5-6

5.3 Biological Monitoring 8-5-6
A. Periphyton 8-5-6
1. Objectives. 8-5-6
2. Methods 8-5-6
3. Rationale 8-5-6
4. Data Analysis 8-5-7
B. Benthos. 8-5-7
1. Objectives. 8-5-7
2. Methods 8-5-7
3. Rationale 8-5-8
4. Data Analysis 8-5-8

CHAPTER 6 HYDROLOGY

6.1 Surface Water Monitoring. 8-6-1
A. Springs and Seeps. 8-6-1
1. Objectives. 8-6-1
2. Methods 8-6-1
B. Surface Water. 8-6-3
1. Objectives. 8-6-3
2. Methods 8-6-3
3. Experimental Design & Rationale 8-6-3

6.2 Groundwater Monitoring. 8-6-11
A. Alluvial Aquifers. 8-6-11
1. Objectives. 8-6-11
2. Methods 8-6-11
B. Deep Oil Shale Aquifers. 8-6-13

1. Objectives. 8-6-13
2. Methods 8-6-13
3. Rationale 8-6-16

CHAPTER 7 REVEGETATION

7.1 Introduction. 8-7-1

7.2 Monitoring Program. 8-7-2
A. Vegetation 8-7-3
1. Parameter 1 - Range Productivity and Utilization. 8-7-3
a. Objectives and Rationale 8-7-3
b. Hypotheses 8-7-5
c. Methods. 8-7-5
d. Experimental Design and Data Analyses. . . 8-7-6
2. Parameter 2 - Browse Utilization. 8-7-6
a. Objectives and Rationale 8-7-6
b. Hypotheses 8-7-6
c. Methods. 8-7-6
d. Experimental Design and Data Analyses. . . 8-7-7
3. Parameter 3 - Species Composition and Percent Cover. 8-7-7
a. Objectives and Rationale 8-7-7
b. Hypothesis 8-7-8
c. Methods. 8-7-8
d. Experimental Design and Data Analysis. . . 8-7-8
B. Soils. 8-7-8
1. Parameter 1 - General Soil Properties 8-7-8
a. Objectives and Rationale 8-7-8
b. Hypothesis 8-7-9
c. Methods. 8-7-9
d. Experimental Design and Data Analyses. . . 8-7-9
2. Parameter 2 - Trace Metals and Conductivity . . 8-7-9
a. Objectives and Rationale 8-7-9
b. Hypothesis 8-7-9
c. Methods. 8-7-9
d. Experimental Design and Data Analyses. . . 8-7-10
C. Fauna. 8-7-10
1. Parameter 1 - Small Mammal Abundance. 8-7-10
a. Objectives and Rationale 8-7-10
b. Hypothesis 8-7-10
c. Methods. 8-7-10
d. Experimental Design and Data Analyses. . . 8-7-11
2. Parameter 2 - Avifauna. 8-7-11
a. Objectives and Rationale 8-7-11
b. Hypothesis 8-7-12
c. Methods. 8-7-12
d. Experimental Design and Data Analysis. . . 8-7-13
D. Summary. 8-7-13

CHAPTER 8 SUBSIDENCE

CHAPTER 9 NOISE

LITERATURE CITED

CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

Tract C-a lease stipulations require compliance with all applicable Federal, State and local statutes, regulations and standards relating to water pollution control, water quality, air pollution control, air quality, noise control and land rehabilitation. Further requirements are to avoid, minimize, and where practicable, repair damage to the environment.

Rio Blanco Oil Shale Project is approaching the development of Tract C-a with a sincere desire to make its activities as free from environmental damage as is practicable. Toward this end, environmental interfaces have been included in all engineering work. This has permitted the development of designs and selection of equipment, alternatives and techniques that will mitigate or eliminate environmental damage.

The health and safety and environmental protection plans presented in this section have a threefold function:

- To set forth the pollution control devices and techniques planned for the project.
- To serve as guidelines for detailed design and equipment selection.
- To serve as guidelines for construction and operation of the various facilities in a manner to mitigate environmental damage as much as practicable.

The concept of development in phases will permit the evaluation of many of the environmental quality control techniques and equipment on a full-scale basis, with time to refine these plans prior to committing vast amounts of resources for the equipment required to implement the Commercial

Phase. Planning has been concentrated in the Modular Development Phase, but the concepts developed are directly applicable to the larger facilities required in the Commercial Phase. In instances where the Commercial Phase will introduce new problems to the environment, those problems are considered separately.

To cause the least possible impact on water quality, a zero surface discharge concept will be employed throughout the entire project. In no instance will contaminated water be discharged to the surface or groundwater courses. Natural drainages will be diverted around operating areas to avoid contamination.

Rehabilitation, including revegetation, will be a continuing program, commencing in the early years with road and power line corridors. As disposal piles are brought to final configuration, revegetation will progress as closely behind the operation as is practical.

The environmental control plans, equipment and techniques presented throughout the DDP and in this section in particular, are based on current knowledge and technology in the field. Actual construction and operation of this project will provide some additional information on materials and processes which will permit changes and improvements to be made in the environmental control activities. RBOSP intends to take every opportunity to eliminate, minimize or mitigate any environmental degradation that may result from the oil shale development.

CHAPTER 2

HEALTH & SAFETY

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER 2
HEALTH AND SAFETY

RBOSP management intends to design, construct and operate this project to provide a workplace as free as possible of hazards to either workers or the public. Therefore, the project management and staff will be fully involved in the project safety effort. This chapter covers the Health and Safety aspects of all operations except underground mining which is covered in Section 2 Chapter 6, Mine Design.

2.1 APPLICABLE REGULATIONS

Pertinent Federal and State health and safety standards and regulations have been reviewed and the project planning has been and will continue to be directed to ensure design compliance. The principal regulations are:

- Code of Federal Regulations (CFR)
  Title 30, Part 57.5-50 Metal and Nonmetal. Mine - Health and Safety - Underground - MESA.
  Title 30, Part 56 - Health and Safety Standards for Sand, Gravel and Crushed Stone Operations.
  Title 29, Part 1926 - Occupational Safety and Health Regulations for Construction.
  Title 29, Part 1910 - Occupational Safety and Health Standards.
  Title 26, Part 18 - Commerce in Explosives.
- Colorado Mining Laws with Safety and Health Rules and Regulations, Bulletin 20, January 1, 1971. Revised April 6, 1976.
- State of Colorado, Occupational Safety and Health Administration, Safety and Health Construction Standards.
- Uniform Building Code.
- National Electrical Code.

- National Electrical Safety Code.
- Various industry standards, such as those of the American Society for Testing and Materials, American Concrete Institute, American Petroleum Institute, American Society of Mechanical Engineers and American National Standards Institute, as appropriate.

During final design and prior to the start of construction, a detailed Health and Safety program for the construction phase will be developed to include the necessary rules and codes to ensure that the facility will be built safely and in full compliance with all applicable regulations. Prior to the start of mining and processing facility operation a detailed Health and Safety program will be developed in a similar manner to cover all operations.

2.2 PERSONNEL RESPONSIBILITIES

The project manager during construction and a member of management during operation will have full responsibility for executing and implementing a program of employee protection and accident prevention. They may delegate authority to expedite and facilitate any application of the program.

A safety engineer, responsible to the project manager (construction phase), or manager (operation phase) will be employed on the project. He will be charged with inspections and investigation of work methods for safe performance, orientation of new employees in safety practices, organization of safety meetings and supervision of first-aid treatment and facilities. He will also be responsible for compiling all necessary records, logs and reports pertaining to safety required by the project and by Federal and State governmental agencies. He will investigate and report all accidents involving personnel or equipment and all damage to property caused by fire, flood or other occurrences.

Safety and other supervisory personnel will orient new employees and be responsible for the work methods and safety procedures followed on work assignments performed in their respective areas of responsibility. With the assistance of safety personnel, supervisory personnel will plan for and conduct periodic safety training meetings. They will comply with safety regulatory requirements generally applicable to the work and follow all directives relating to safety instituted by management and the safety engineer consistent with company policy and appropriate regulatory codes.

Subcontractors will be required to comply with the project safety program, standards, procedures, stipulations and regulations.

All employees must learn and comply with all safety rules and regulations applicable to their work and to the general safety of other workers on the project. Management will be responsible to make the project a safe place to work. However, each employee will be responsible for supporting management to provide a safe place to work, to protect himself and his fellow workers against injuries and to report all safety hazards at once to project supervisors.

2.3 SAFETY AND ACCIDENT PREVENTION PROGRAM

A management safety committee will be formed with at least one member from each major department. The committee will meet monthly to:

- Promulgate and review safety procedures and policies.
- Discuss major accidents pointing out the causes and how the accidents could have been avoided.
- Discuss safety hazards and suggest methods to control or eliminate them.
- Develop continuing safety programs with emphasis on problem areas.
- Review progress of work on any necessary safety improvements.

Results of these meetings will be appropriately communicated to all employees through regular supervisory channels.

The safety engineer or other delegated person will make routine inspections of work areas. He will immediately bring any inadequate or deficient measure or unsafe work practice to the attention of the appropriate supervisor for correction. The safety engineer will inform the appropriate manager of all deficiencies that cannot be corrected immediately or that may result in damage to facilities or equipment or that create hazardous public exposure. All flammable-materials and explosives storage areas, shops, warehouses and other buildings will be inspected at regular intervals.

Appropriate mechanical safety inspections will be part of the equipment preventive maintenance program and as such will be the responsibility of both field and shop mechanical department supervisors and operating department supervisors. Records and reports will be an important part of the preventive maintenance program. Periodic spot check inspections may be made as required.

Management will be responsible for instructing each employee to recognize and avoid unsafe and hazardous conditions connected with his particular job and to be aware of and understand those safety regulations applicable to his working environment. As a minimum, the project's safety and health training program will include:

- Initial indoctrination by the safety supervisor or other representative of management. This indoctrination will cover general information about the safety program and the safety policies and regulations, as well as details relating to specific safety rules.
- Prework briefing and demonstration by individual supervisors. This phase will familiarize each employee with company approved safe operating and working procedures and with existing or potential job hazards with regard to the specific tasks to be performed by the employee.

- Periodic safety training meetings. These meetings, which will be held by supervisors, will emphasize the safety rules, penalties for violating rules and standard codes, the causes of accidents in a particular trade and ways of preventing accidents. A record of these meetings, including major topics discussed and names of employees in attendance, will be maintained.
- Follow-up field training and supervision to ensure that safety rules and regulations are fully understood and are being complied with. On-the-job safety training is recognized as one of the most effective ways of educating workers.

2.4 REPORTS AND LOGS

The management and/or the safety engineer will be responsible for establishing and complying with record keeping and reporting requirements. Records and reports will include:

- Personal injuries and treatments received.
- Accident investigations.
- Reports to compensation carrier.
- Requirements of State and Federal agencies.
- Disabling (lost-time) accidents/injuries.
- Property damage.
- Testing logs, as required for dust, gas or explosive work.

2.5 SPECIAL CONCERNS

In addition to the information contained in this chapter, other portions of this section also concern health and safety, either directly, as in the case of Chapter 3, Fire Prevention and Control, or indirectly, in other chapters. Sections 2, 3, 4, and 5 also contain information relative to safety design features.

A. Airborne Contaminants - Wherever employees are exposed to concentrations of dust or fumes that are potentially harmful, a monitoring program will determine the levels of exposure and concentrations of the contaminants. Exposure can be alleviated by the proper use of personal protective equipment. Controlled-atmosphere control stations will be provided for operators where required.

Harmful concentrations of fumes and dust are shown in Tables 6-2-1 and 6-2-2, respectively.

Table 6-2-1

HARMFUL CONCENTRATION OF AIRBORNE CONTAMINANTS*

Chemical Compound or Product	Concentration (ppm)
Ammonia	50
Benzene	25
Carbon dioxide	5000
Carbon monoxide	50 (.005% by volume)
Chlorine	1
Gasoline	500
Hydrogen cyanide	10
Hydrogen sulfide	10
Methane	500 (.05% by volume)
Naphtha (petroleum)	100
Nitrogen oxides	25

*Colorado Mining Laws, Rules and Regulations, Bulletin 20, January 1, 1971, Part 71.2

Table 6-2-2

HARMFUL CONCENTRATIONS OF DUST*

Type of Dust	Million Particles Per Cubic Foot
Without free silica	50
With free silica	$250 \div (\% SiO_2 + 5)$

*Colorado Mining Laws, Rules and Regulations, Bulletin 20, January 1, 1971, Part 49.3

B. Noise Control - See Section 6 Chapter 4.

C. Explosives - The Alcohol, Tobacco and Firearms Division of the U.S. Treasury Department has jurisdiction to enforce Federal regulations pertaining to commerce in explosives, which also include the storage and handling of explosives. Generally, State and Federal mining laws regulate the storage and handling of explosives as well as their use. However, these regulations are compatible with and do not supersede the Treasury Department regulations. See Section 5, Chapter 9, Explosives Storage and Handling, for a discussion of the facilities being provided.

The storage and handling of explosives will be effectively regulated by the Colorado Bureau of Mines and the Mining Enforcement and Safety Administration. However, it is necessary to comply with the laws and regulations as enforced by the Treasury Department and defined in 26 CFR, Part 181. Salient features of these regulations are discussed below.

1. Definition of Explosives - Each year the Treasury Department publishes a list of recognized explosives that are regulated by law. Unmixed ammonium nitrate is not classified as an explosive. However, the mixed form of ANFO (ammonium nitrate-fuel oil), which is sensitive to a number 6 blasting cap, is classified as a blasting agent.

2. Classes of Explosives - Explosives are classified as: 1) high explosives; 2) low explosives; or 3) blasting agents. High explosives (dynamite, for example) can be detonated by a blasting cap when unconfined. Low explosives (black powder, for example) can be caused to deflagrate when confined. Blasting agents include less sensitive explosives, such as ANFO.

3. Storage Facilities for Explosives - There are five types of storage facilities for explosives:

Type 1 - permanent storage for high explosives

Type 2 - portable indoor/outdoor storage facilities for high explosives

Type 3 - portable outdoor facilities for temporary storage of high explosives

Type 4 - facilities for storage of low explosives or blasting agents

Type 5 - facilities for storage of blasting agents

Strict construction codes and limitations apply to each of the five types of storage facilities for explosives. These codes and limitations are detailed in 26 CFR, Part 181, Subpart J. All storage facilities for the project will meet or exceed these codes.

ANFO in bags or cartridges will be stacked to allow free access by authorized persons and permit circulation of air. ANFO stored with other explosives is considered as equal weight with other explosives and will be separated from them by at least 24 inches in a manner to prevent fuel oil contamination.

The American Table of Distances, published by the Institute of Makers of Explosives, specifies the distances at which explosives can be safely stored from other structures (public highways, buildings or railways). Also, the tables specify minimum separation distances for blasting agents and high explosives. The amount of explosive to be stored and the design of the storage facility are functions that define the minimum separation distance between multiple storage bunkers, or between storage bunkers and inhabited buildings. The tables will be used in the design of storage and handling facilities for explosives and blasting agents.

4. Transport of Explosives - The guidelines listed below will be followed in transporting explosives and considered, along with pertinent regulations and specifics of the site, in developing detailed safety plans for operations.

- Vehicles containing explosives or detonators will be posted with proper warning signs.
- When vehicles containing explosives or detonators are parked, the brakes will be set, the motive power shut off and the vehicle blocked securely to prevent it from rolling.
- Vehicles containing explosives or detonators will not be taken to a repair garage or shop for any purpose.
- Vehicles used to transport explosives, other than blasting agents, will have substantially constructed bodies and no sparking metal exposed in the cargo space, and they will be equipped with suitable sides and tailgates.
- Explosives or detonators will be transported at times and over routes that expose the minimum number of people.
- Other materials or supplies will not be placed on or in the cargo space of a conveyance containing explosives, detonating cord or detonators, except for safety fuse and except for properly secured, nonsparking equipment used expressly in the handling of such explosives, detonating cord or detonators.
- Only the necessary personnel will be permitted to ride on or in vehicles containing explosives or detonators.
- Vehicles containing detonators or explosives, other than blasting agents, will not be left unattended, except in blasting areas where loading or charging is in progress.

5. Use of Explosives - Personnel using or handling explosives or detonators will be experienced and understand the hazards involved; trainees will do such work only under supervision of and in the immediate presence of experienced personnel. All blasting operations will be under the direct control of the appropriate supervisor.

Holes to be blasted will be charged as near to blasting time as practical and such holes will be blasted as soon as possible after charging has been completed. Unused explosives and detonators will be moved to a safe location as soon as charging operations have been completed. Areas in which charged holes are awaiting firing will be guarded to prevent

unauthorized entry. Faces and muckpiles will be examined for undetonated explosives after each blast and any undetonated explosives found will be disposed of safely.

Holes will not be drilled where there is danger of intersecting a charged or misfired hole. Workers will not be permitted to return to a misfired hole until at least 15 minutes have elapsed (for electric caps). If a safety fuse has been used, 30 minutes must elapse before workers may return.

Smoking will not be permitted within 25 feet of any explosives or detonators. Other detailed rules will be promulgated as required to ensure the safe storage, handling and use of explosives at this project.

D. Electrical Facilities

1. Cables and Power Lines - Open conductors will not be used in hazardous locations (due to gassy or dusty atmosphere containing corrosive fumes) or in explosive magazines, changerooms, underground repair shops, compressor rooms or battery-charging stations. Such wiring will be in conduit or approved cable type. Electric wiring in any magazine will be in conduit, protected by fuses, with no line of wiring within 5 feet of explosives stored therein. Potential will not exceed 40 volts on bare signal wires accessible to contact.

Power lines will be protected against voltage surges, short circuits and excessive loads, and circuit breakers or fuses will be provided. In addition, they will be separated or insulated from water, air and telephone lines. High-potential utility-pole guy wires will meet National Electric Safety Code requirements for grounding and insulators.

Power cables over 650 volts will be of a type approved for the service intended and will be installed according to the National Electrical Code and the National Electrical Safety Code. Trailing electric power cable will be connected to mobile equipment so as not to cause danger to the

joints or terminal screws or fittings. Energized cable will be handled only with approved hot-line tools and protective equipment.

2. Grounding - Metallic frames, fences, buildings, shielding and conduit, as well as motor casings, transformers, switch gear and all other electrical equipment that may be energized through insulation failure or contact with other energized parts, will be grounded. Continuity and resistance of ground circuits will be tested following installation. Ground wire will be attached to ground before the other end is attached to equipment. Electric blasting circuits from firing switch to blast area will not be grounded. Lightning arrestor grounds will be separated in the earth at least 25 feet from ground fields of systems supplying portable equipment.

3. Lightning Protection - Power lines, telephone lines and electrical equipment will be protected against lightning according to the National Electrical Safety Code, MESA standards and Colorado Mining Laws and Regulations.

4. Electrical Equipment - Hand-held or portable electrical equipment will not be operated above 500 volts, with a maximum voltage of 250 volts between each conductor. Equipment will not be operated closer than 10 feet to high-voltage power lines, unless such lines are de-energized or other precautionary measures are taken. Electrical equipment will be installed to be readily and safely accessible for maintenance. Where access or travel around stationary equipment or switchgear is necessary, a minimum clearance of 3 feet will be provided.

Circuit breakers or fuses of the correct type and capacity will be installed on all electrical equipment, including trailing cables, to protect against overloads, short circuits, and voltage surges. Electrical equipment and circuits will be provided with enclosed safety switches of approved design, construction and installation. Disconnecting safety switches will be installed on all main power circuits on which separate circuits have separate switches. All switches, circuit breakers,

starting boxes, power controls and other electrical equipment will be of adequate capacity and safe design, and will be mounted on suitable insulating material.

E. Machinery and Equipment - All machinery and equipment will be designed, installed and operated in accordance with all appropriate regulations and safe practice guides to provide a safe working environment. All necessary safety devices and equipment will be provided to guard workers against injury.

F. First Aid and Medical Facilities - Project management will provide for adequate facilities and qualified personnel to ensure prompt and efficient first aid and medical care of injured employees. Personnel qualifications, facilities, services and supplies will conform to the good practice standards of the American Medical Association.

First aid stations will be established to comply with the requirements of the project. The facilities provided will be governed by the number of personnel employed on the project and in consideration of other medical care and facilities readily accessible and available to the work. Adequate identification and directional markers will be provided to denote the location of all project first aid stations.

Standby automotive units will be provided for emergency transportation. Each unit will be properly equipped to accommodate a stretcher and allow for prompt, comfortable transportation of personnel to medical or hospital facilities. When not available on the project, the project management will, in advance, make necessary arrangements for standby emergency transportation of injured employees. Medical and hospital arrangements will be made with nearby community facilities. All emergency telephone numbers will be posted conspicuously at appropriate locations.

In the absence of qualified doctors, nurses or first aid attendants, selected supervisory personnel will hold current American Red Cross or U.S. Bureau of Mines first aid certificates. Management will encourage all supervisors to become qualified for first aid certificates. At

least one person with a valid certificate in first aid will be on duty at all times.

First aid kits will conform to Bureau of Mines standards and will consist of a weatherproof container with individually sealed packages for each type of item. First aid kits will be fully equipped before being sent out on each job and checked weekly to ensure that expended items have been replaced.

Standard Stokes type or equivalent stretchers and blankets will be strategically located in the work areas. They will be wrapped in vis-queen or other waterproof material and stored in plainly marked and sealed waterproof containers.

G. Health and Sanitation - Drinking water will be secured from sources approved by Federal, State or local health authorities. It will be dispensed by means that will prevent contamination between source and consumer. The use of common drinking vessels will be prohibited. Where single-service cups are used, both a sanitary container for unused cups and a waste receptacle for used cups will be provided. Any container used to distribute drinking water will be clearly marked as to the nature of its contents and will not be used for any other purpose. Outlets for nonpotable water, such as water for industrial or fire fighting purposes will be conspicuously posted, "Danger, Water Unfit for Drinking, Washing or Cooking".

Sanitary facilities will be provided in the number and type that meet Federal, State and local health requirements. These facilities will be maintained and the sewage disposed of in accordance with appropriate sanitary requirements under good public health practice and standards. (See Section 6, Chapter 6, Water Quality Control).

Reusable personal protective equipment will be sterilized before being issued to another person. Items requiring sterilization include safety glasses and goggles, rubber boots or shoes, rain suits or coats, hard

hat bands, suspensions and winter liners, and shells for masks or respirators. Protective earplugs are considered expendable protective items.

All garbage or refuse will be disposed of in designated areas in a manner as stipulated by lease requirements and local or State regulations. See Section 6, Chapter 9, Solid Waste Control, for details.

Required washing facilities will be maintained in a sanitary condition and provided with adequate hot and cold water, soap, individual towels and receptacles for disposal of waste. Emergency showers and eyewash facilities will be provided as required.

H. Signs and Posters - Signs and posters of appropriate design and bearing standard pertinent regulations will be used to convey warnings, directions and instructions to personnel and the public, as required by the lease and other applicable regulations. The observance of such safety and accident-prevention signs will be strictly required of company employees and visitors while on the project.

I. Personal Protective and Life-Saving Equipment - Use of such protective equipment will be complied with as required by regulations and recommended by safety standards. Hard hats, hard-toed shoes, safety belts, goggles, respirators, earplugs and other personal protective equipment will be required where needed. Employees are expected to be responsible for the use and care of this equipment. Life preservers, work vests, ring buoys, nets, safety skiffs or other marine life-saving equipment will be provided for use of personnel working adjacent to or over water.

J. Protection of the Public - Tract areas will be examined for hazards to the public, and suitable controls will be established to prevent access by the public to such hazardous areas as contaminated water storage ponds, unstable slopes, haul roads, construction areas, etc. Suitable access to safe water impoundments and nonoperating areas will be provided to encourage safe use of the area by the public.

K. Toxicology Studies - The potential health hazards of exposure to oil shale ore, shale oil, processed shale, and materials leached out of or extracted from these substances have attracted major public attention in the last few years. Known cancer-causing agents (carcinogens) such as benzo(a)pyrene (BaP) do occur in these oil shale derivatives. Some studies, however, indicate that the levels of BaP in oil shale projects are actually lower than in many other naturally occurring substances (Atwood and Coomes, 1974).

RBOSP initially addressed this potential problem in August 1976 by designing a testing program to identify levels of potential toxic substances likely to occur in shale oil and its derivatives and test their effects on laboratory animals and humans. Once the decision was made to redesign the mining plan to utilize the Modified In Situ method, this toxicology testing program was redesigned to meet current needs.

The toxicology testing program will provide information on short-term (subacute) effects and chronic (two-year) exposures. Methods of testing included:

- Inhalation tests - two-year (monkeys and rats)
- Acute inhalation tests - 14-day observation (rats)
- Acute oral administration - 14-day observation (rats)
- Subacute dermal study - 3-week repeated application (rabbits)
- Acute dermal application - 14-day observation (rabbits)
- Subacute dietary administration - 13-week observation (rats)
- Subacute oral administration - 13-week observation (dogs)
- Acute eye irritation - 7-day observation (rabbits)
- Skin painting - 80-100-week observation (mice)
- Subacute inhalation (rats and monkeys)
- Repeated insult patch test (humans - skin sensitization)

Eleven oil shale constituents or derivatives will be used during the tests, including oil produced by Modified In Situ processing. The testing program is depicted in Table 6-2-3.

TABLE 6-2-3

PROGRAM OF TESTING OF SHALE MATERIALS

Material to be tested	Tox. Screen	Subacute Skin	Tox. Inhal.	Sensit.	Chronic Skin	Chronic Inhal.	90-Day Feedings
Shale - raw	X	X	X	X	X	X	-
Shale - Processed (Tosco II)	X	X	X	X	X	X	-
Kerogen	-	-	-	-	X	-	-
Kerogen (Colony)	-	-	-	-	X	-	-
Benzene Extract of Processed Tosco II Shale	-	-	-	-	X	-	-
Benzene Extract of Water Extract of Processed Shale	-	-	-	-	X	-	-
Water Extract of Processed Shale	-	-	-	-	-	-	X
Heavy and Medium Fractions of Tosco II Shale Oil	X	X	X	X	X	-	-
Centrifuge Sludge	-	-	-	-	X	-	-
Modified In Situ origin shale oil	X	X	X	X	X	-	-

This testing program does not address environmental or human hazards from extraneous gases, stack effluents, or uptake of trace elements into plant life. These effects are addressed, however, in other sections of the DDP (See Section 6, Chapter 5.7, Air Quality Modeling; Section 6, Chapter 8.4, Revegetation; and Section 8, Chapters 4, Terrestrial Ecology Monitoring, and Chapter 7, Revegetation Monitoring).

Toxicity tests will be scheduled to optimize feedback and allow incorporation of study results from one phase of the program to the next. Toxicity screening will be started first to provide input for subacute and chronic testing. Skin testing will also be started at the onset to allow adequate time to complete the 80 to 100-week test period. Feeding and human skin sensitization tests will begin several months after the program has been initiated. Subacute and chronic testing will be initiated as soon as adequate information from screening has been obtained. The projected study period for this program is 2½ to 3 years; however, results from some testing programs will be available much sooner.

Through the use of conventional refinery practices for handling potentially toxic substances, coupled with the timely results from the toxicity programs of API and Rio Blanco Oil Shale Project (which will help refine these practices), the detrimental health effects to RBOSP employees or the public due to toxic substances contained in oil shale or its products and waste will be minimized.

CHAPTER 3

FIRE PREVENTION & CONTROL

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER 3
FIRE PREVENTION AND CONTROL

Fire prevention and control is of particular importance in the project construction, mining and processing activities due to the unusually large concentrations of explosives, flammable liquids and combustible materials in a relatively confined area. The plan outlined in this chapter includes preventive measures, emergency procedures, applicable codes and regulations and training methods involved in establishing and administering an effective fire prevention and control plan for oil shale mining, Modified In Situ retorting, and processing operations.

The Rio Blanco management will designate a member of the supervisory staff as the project fire control coordinator to be responsible for the operation of the fire prevention and control plan.

3.1 APPLICABLE REGULATIONS

Recommended practices and standards of the National Fire Protection Association and applicable Federal and Colorado fire protection and prevention regulations will be followed in the development and application of project fire prevention and control programs. A listing of the principal applicable regulations follows:

- Tract C-a Oil Shale Lease
- Fire Protection Handbook, National Fire Protection Association, Thirteenth Edition, 60 Batterymarch Street Boston, MA 02110.
- National Fire Codes, National Fire Protection Association, 1975 Edition, 470 Atlantic Avenue, Boston, MA 02210.
- Colorado Mining Laws, Bulletin 20, Colorado Bureau of Mines, 1845 Sherman Street, Denver, CO 80203.

- Code of Federal Regulations (CFR)
  Title 30, Part 57.5-50, Metal and Non-metallic Mines, Health and Safety, Underground. MESA
  Title 30, Part 56, Health and Safety Standards - Sand, Gravel, and Crushed Stone Operations, Bureau of Mines, U.S. Department of the Interior.
  Title 29, Part 1926, Sub-part F, Construction Safety and Health Regulations, Occupational Safety and Health Administration, U.S. Department of Labor.
- Safety and Health Rules and Regulations, Colorado Occupational Safety and Health Administration.

3.2 CONSTRUCTION

Fire prevention during construction is of particular concern because of the varied and scattered types of activities and the number of people and equipment items involved. Also, many of the subcontractors and tradespeople working on the project may be unfamiliar with fire prevention procedures and rules.

A. Tools and Equipment - A supply of fire fighting tools and equipment will be furnished to each construction site. These items will be kept at the respective construction sites at all times during project construction. They will be so located as to be readily accessible for fire use, and will be reserved and used exclusively on fires and not in construction operations. Fire boxes will contain enough tools to adequately equip the men employed by the contractor during any given 8-hour shift. One fire box, normally containing 5 round-pointed shovels, 2 double-bitted axes, and 3 Pulaskis or mattocks, will be provided for each 10 men.

Chain-saw crews and dozers working anywhere on the project will be immediately available for fire control within the project area.

B. Special Precautions - The following special precautions will be taken:

- Surface Blasting - During the precautionary period (generally May 15 through November 15), a watchman, equipped with a size 0 or larger round-pointed shovel, will patrol the suface blasting area looking for fires.
- Welding - Welding will be accomplished in construction camp service areas when possible. If welding is required at a field location, it will be performed at a location where all flammable material has been cleared away for a distance of 15 feet around the area. One filled backpack pump, a shovel and an axe will be maintained at each welding site during welding operations.
- Spark arrestors - All diesel and gasoline powered engines, both mobile and stationary, will be equipped with approved serviceable spark arrestors. Exhaust-driven turbochargers are efficient spark arrestors.
- Lunch and warming fires - The building of open lunch and warming fires will be prohibited.
- Smoking - During the normal precautionary period (May 15 through November 15 as recommended by the U.S. Forest Service), smoking will be permitted only in safe places, such as along roads, in truck cabs, or in designated areas where all flammable material has been cleared away. Smoking will not be permitted in buildings containing gasoline, diesel fuel, oil or explosives, and "No Smoking" signs will be posted in such buildings.
- Power saws - Each gasoline power saw will be provided with a muffler in good condition. Each saw operator will have one chemical-pressurized fire extinguisher of not less than 8 ounces by weight and one size 0 or larger round-pointed, long-handled shovel. Spill-proof metal cans will be used for refueling.

- Storage and parking areas - Areas for construction support facilities, equipment service, parking, gas and oil drum storage and explosive storage will be cleared of all flammable materials for a distance of 50 feet. Small stationary engine sites will be cleared of all flammable materials for a distance of 15 feet. Flammable and explosive storage areas will be labeled as such, and "No Smoking" signs will be prominently displayed.
- Oil filters, cartridges, and oily rags - Used and discarded oil filters, cartridges and oily rags or waste will be collected and taken to an approved sanitary landfill. Glass jugs or bottles will not be used as gas, oil or waste containers.

C. Open Burning - Open burning is not contemplated as a general practice on the project. Any open burning will require specific application to and approval of the Area Oil Shale Supervisor. However, in the event that such burning is required and approved, the following controls will apply:

- No burning will be allowed without advance approval of the project fire control coordinator.. All oral approvals will be confirmed in writing. Before burning is authorized, weather forecasts will be secured from the U.S. Weather Bureau. No burning will be permitted during turbulent weather conditions or when a jet stream is within 50 miles of the burn site.
- A burning permit will be obtained from the Colorado Air Pollution Control Division prior to any burning. A copy of the permit will be filed by the project fire control coordinator.
- The coordinator may require burning in one area to be completed and extinguished before burning is started in another area. Based on the National Fire Danger Rating System, if Manning Class III or above is reached, mop-up of unextinguished piles will be immediate and complete with followup checks made the next day to ensure that all fires are "dead out". The project fire control coordinator will determine from appropriate agencies when Manning Class III is reached.

- Fires started in the morning will be allowed to burn out by noon the same day and mopped up so as to be "dead out" before quitting time that day.
- A tractor with blade will be available during all burning to widen fire lanes and to stop advancing fires as necessary.
- The burning of any material will be done within a cleared right-of-way to the extent possible. All debris will be piled into large, compact, dirt-free piles for burning.
- A fire lane to bare soil, not less than 12 feet wide and within 20 feet of the pile, will be constructed completely around each pile of debris under all conditions, except when there is snow cover of 4 inches or more.

3.3 MINING

The fire prevention and control plan for both the Modular Development Phase and Commercial Phase mining facilities will be based upon the following:

- The design and layout of both operations predicated upon mine design principles to minimize the likelihood and severity of fire occurrence and to provide the maximum security for escape the the ability to fight fires underground.
- The provision of adequate fire fighting equipment in the mine and on all mobile equipment.
- The provision of a redundant circuit communication system, a highly trained mine rescue and fire fighting team, and permanently installed fresh air stations and escape capsules.
- A training program to instruct all mine personnel, in addition to normal mine operation, in fire fighting procedures and details of the fire prevention, control and escape plan.
- A rigorous safety program incorporatng regularly scheduled inspection of the mine operating and fire fighting equipment.

Design specifications for all mining equipment will either meet or exceed the requirements of the Tract C-a lease and will conform to the latest editions of codes and regulations of the Federal, State or local agencies having jurisdiction.

The principal mine fire fighting agents will be water, foams, dry chemicals and steam. The fire protection system will be designed so that the agents needed in a particular fire situation will be available in the right places and in quantities sufficient for rapid containment.

All underground mine fire fighting equipment will be regularly tested and maintained in first class operating condition. Records will be kept to ensure that maintenance of all equipment is performed on schedule.

3.4 PROCESSING FACILITY

The fire prevention and control plan for both the Modular Development Phase and Commercial Phase processing facility incorporates a four-fold approach:

- Engineering design and plant layout to minimize the likelihood and severity of fire occurrence.
- Training program to instruct all plant personnel in normal plant operation, as well as in fire fighting procedures and details of the fire prevention and control plan.
- Adequate fire fighting equipment available throughout the processing facility for use by trained personnel, together with an effective communication system to coordinate fire fighting efforts.
- Safety program incorporating regularly scheduled inspection of processing facility operating and fire fighting equipment.

The major considerations and guidelines for fire prevention and control in the processing facility are described below.

A. Plant Design and Layout - Design specifications for all processing equipment and storage facilities will either meet or exceed the requirements of the Tract C-a lease and recognized standards for the oil refining industry. The principal non-governmental agencies that supply codes, standards and other widely accepted industry practices include:

American Petroleum Institute (API)
American Institute of Steel Construction (AISC)
American Society of Mechanical Engineers (ASME)
American National Standards Institute (ANSI)
American Concrete Institute (ACI)
American Society for Testing and Materials (ASTM)
Hydraulic Institute
Institute of Electrical & Electronics Engineers (IEEE)
National Electrical Manufacturers Association (NEMA)
National Fire Protection Association (NFPA)
Oil Insurance Association (OIA)

In addition, the design and construction of the plant will conform to the safety requirements of the latest editions of codes and regulations of the Federal, State or local agencies having jurisdiction.

1. Process Units - Process vessels, pumps, piping and associated equipment will be designed to withstand temperature and pressure conditions in excess of the normally expected operating conditions. These design conditions allow for temporary excursions from normal conditions and reduce the probability of equipment failure before corrective measures can be taken. Construction materials will be selected specifically for the process fluids involved, and corrosion allowances will be included to provide extra metal thickness for potential corrosive attack over the life of the process units. To the maximum practical extent, automatic controls will be installed that will operate in a fail-safe manner to minimize dependence on the human element. Indicating, recording and controlling devices monitoring pressures, temperatures and flow rates will be integrated with all processing equipment. In addition, alarms

and shutdown systems will be used to warn of unusual process conditions and to shut down operation before equipment failure can occur. All of these devices will serve to maintain proper operating conditions and to prevent occurrences that might result in explosions or release of flammable materials from the process units.

Process unit layout is an essential part of controlling and minimizing loss from potential fires. The plant layout follows modern refinery practices and is in accordance with insurance underwriters' recommendations. Some considerations relative to the process unit plot plan are listed below:

- Administration buildings, medical buildings, fire station and utility areas will be located so that they will not become involved in a fire or explosion originating in the processing or tankage area.
- Storage tanks will be located so that, in the event of failure, their contents cannot flow by gravity to feed a fire in a process or service area.
- Spacing between process units will be at least 50 feet to permit maintenance and hot work to be performed while adjacent units are operating and to minimize mutual involvement of process units in case of fire.
- In locating flares, consideration will be given to wind direction, exposure to adjacent equipment and heat release. Elevated flares will be at least 100 feet above grade and a minimum of 200 feet from operating plants.
- Fire drill equipment and training area will be located downwind of the plant with a minimum clearance of 200 feet from property lines and operating equipment. The area reserved for this purpose will be at least 100 feet square, adjacent to a road and accessible to water supply.
- Access for fire trucks and associated equipment will be provided to all process areas.

Within the battery limits of a single process unit, the following guidelines for equipment location will apply:

- No smoking will be allowed.
- Storage tanks containing flammable material will not be located within battery limits.
- Control houses will be located at the edge of battery limits at least 100 feet from fired heaters.
- Fired heaters will be at least 50 feet from processing equipment handling light hydrocarbons. Individual furnaces will be at least 25 feet apart. Boilers will be located as far from process units as practical.
- Air-cooled exchangers will preferably be located in a clear area with no equipment underneath that might be involved in a fire.

In addition, fireproofing up to 30 feet above grade will be provided on main structural supports for vessels, towers and pipe racks located within processing areas.

2. Storage Facilities - Facilities for storing large quantities of hydrocarbons will be designed to minimize the possibility of fire and spillage. The layout and construction of storage tanks will follow the requirements of the Tract C-a lease, as well as recommendations and standards set by the NFPA and the API. Fabrication materials for storage tanks will be selected specifically for the fluid to be stored.

All product and intermediate storage tanks will be situated in a tank farm which will be segregated from the processing areas. Spacing between adjacent tanks and between tanks and process areas will be in accordance with the appropriate NFPA codes or local regulations. In general, the clear distance between tanks will be one-half the greatest dimension of the smaller tank. This clearance will enable fire fighting equipment and personnel to safely approach and control a tank fire. In addition, cooling water streams can be directed at tanks adjacent to one

involved in a fire to prevent overheating and structural damage to the adjacent tanks.

All tanks, situated singly or in groups, will be surrounded by dikes which will form spill containment basins. The dikes will be engineered in accordance with requirements of the lease and NFPA standards, as a minimum, and will serve to reduce the possible spread of fire outside the originating diked area. Interior surfaces of diked areas will be impermeable and each area will be designed for drainage of spills away from tanks into a gathering basin. The dike height will be kept as low as practicable to contain the desired volume of storage with a maximum height of 6 feet set to avoid obstruction of fire fighting equipment. Furthermore, dikes will be located so that fire fighting equipment will have access to any tank with not more than one dike intervening. Also, no smoking will be allowed in tankage areas.

B. Plant Inspections - Periodic inspections of process equipment and tankage will be made as part of the plant maintenance program. While primarily designed to avoid unscheduled downtime and maintenance, these inspections will also serve to detect and prevent potentially hazardous conditions arising from equipment failure. Radiographic and ultrasonic techniques will be used to examine the condition of pressure vessels, furnace tubes, storage tanks and piping while process units are on-stream. Combined with internal inspections made on maintenance turn-arounds, these examinations will provide corrosion histories for each piece of equipment so that replacement schedules can be established. This procedure will ensure that equipment items are removed from service before normal wear can result in catastrophic failure.

Unscheduled plant inspections will be made regularly by the plant safety committee to check on general adherence to safe practices in daily operation. Irregularities and potential hazards will be reported to line supervisors as well as plant management for corrective action. The plant fire teams will assume responsibility for regular inspection of all fire fighting equipment.

C. Fire Protection Equipment - The principal fire fighting agents will be water, foams, dry chemicals and steam. The fire protection system will be designed so that the agents needed in a particular fire situation will be available in the right places and in quantities sufficient for rapid containment. In setting the size of the fire protection system, the "single-risk concept" will be employed. This concept is based on the assumption that there will be only one major fire in the processing facility at any given time and that that fire will be confined to a single fire risk area. Essentially, the total capabilities of the fire protection system can be employed against that fire.

D. Fire Protection Water System - The system and equipment for supplying fire protection water will be designed in accordance with recommendations of the National Board of Fire Underwriters. A tank with a storage capacity capable of supplying the fire protection water requirements continuously for 6 hours will be provided. Pumping capacity will be provided by two or more pumps, rated to maintain minimum hydrant pressure of 100 psi at design flow. For optimum reliability, different types of pump drives will be used. While electric motor-driven pumps are most suitable for remote or automatic starting, at least one pump will be equipped with an internal-combustion drive.

Fire protection water will be distributed throughout the processing facility by an underground system of fire mains in a grid and loop configuration. Sufficient block valves will be provided in the mains so that sections of the system can be isolated without undue interruption of the fire protection capability. All piping and connections to monitors and hose reels will be protected against freezing.

Hydrants will be located so that any major piece of equipment will be covered by at least two hydrants. In general, a spacing of 150 to 300 feet will be maintained between hydrants. Fixed monitors in processing areas will be spaced 150 feet apart and positioned so as to be accessible during a fire. Hydrants and monitors will be located at least 50 feet from any equipment to be protected. Fixed water spray or deluge systems

will be used to protect facilities where application of water by hose or monitors would be difficult or dangerous, as well as isolated or unattended facilities and storage areas where delayed application of water could result in serious fire losses.

The fire protection water storage capacity and number of pumps required for the processing facility in the Modular Development and Commercial Phases are tabulated below.

Phase	Storage Capacity (million gallons)	Number of Pumps Rated at 750 gpm	Number of Pumps Rated at 1000 gpm
Modular Development	.25	2	0
Commercial	5.0	2	2

E. Major Equipment - Specially designed and equipped fire trucks will be provided to combat oil fires. These trucks will be capable of pumping volumes of foam solution for storage tank and spill fire protection. Supplementary quantities of foam concentrate will be stored in mobile tank trucks or trailers for use where needed.

The processing facility will have available one or more fire trucks, equipped with 1000 to 1500-gpm water pumps and automatic foam proportioning equipment and capable of carrying 500 to 1000 gallons of 3% foam concentrate. At least one unit will be a combination foam-dry chemical truck capable of delivering dry chemical either alone or simultaneously with foam or water. The supplementary foam storage capacity will equal the foam capacity of the fire trucks. This storage capacity is based on the delivery rate required to extinguish a fire in the largest cone roofed tank. A suitable building or shelter will be provided to house and service mobile fire vehicles and miscellaneous fire equipment. This facility will be located along a main plant road in a safe area, remote from the processing areas, but convenient to fire fighting personnel.

Hose carts will be provided to get cooling water on equipment quickly and to supplement hoses carried on fire trucks. One or more hose carts

will be located in each fire risk area, depending on the quantity of water that can be applied from monitors and other equipment.

Two-wheeled, pull-type foam carts, which can be easily handled by one man, will be provided at selected locations in the processing facility. These carts will be stocked with a drum of foam concentrate and an inline proportioner to operate from hydrant water. Turret nozzles and hydrants will be strategically located throughout the processing area.

Portable extinguishers will be provided for immediate use on fires at their incipiency. Dry-chemical extinguishers will be located in process areas, laboratories, buildings, pumping areas and similar locations where Class "B" fires may occur. Travel distance to a single extinguisher will be not more than 50 feet. One or more two-wheeled, 150-pound, dry-chemical extinguishers will be provided for each fire risk area. In addition, carbon dioxide extinguishers equipped with non-conductive discharge horns will be provided for protection of electrical equipment.

Cone-roofed storage tanks will be equipped with piping connections designed for subsurface injection of foam. This technique, the most recent development in foam application for fighting tank fires, is fully endorsed by the NFPA. Portable foam towers will also be provided for pumping foam over the top of tank shells directly onto the oil surface.

All fire fighting equipment will be regularly tested and maintained in first class operating condition. Records will be kept to ensure that maintenance of all equipment is performed on schedule.

F. Communication System - An in-plant system for emergency communication is essential to alert and call personnel in the event of a fire or other hazardous situation, to inform personnel of actions required, to receive and transmit reports at the scene of an emergency, and to call and coordinate efforts with outside groups that will provide aid. To ensure rapid notification and sounding of the plant fire alarm, a separate telephone number will be assigned for fire reports and a separate

telephone, equipped with a loud alarm, will be provided at a constantly manned point to receive emergency calls. The plant siren, coded to designate the general area of emergency, can be actuated from this point. Telephone call lists will be established to summon aid when manpower is limited. Walkie-talkies and two-way radio equipment will be provided in fire vehicles to help coordinate fire fighting efforts. These backup systems are essential in the event the plant telephone system is damaged.

3.5 MOBILE EQUIPMENT

All self-propelled mobile equipment will be provided with suitable fire extinguishers. In addition, specialized equipment will be provided with special extinguishers as follows:

- One portable fire extinguisher having a rating of at least 20 BC units will be provided on all tank trucks or other vehicles used for transporting flammable liquids.
- A fire extinguisher with a 5 BC rating or higher will be placed in a readily accessible location at the operator stations or cabs of cranes, derricks, hoists, elevators and conveyors.
- Self-propelled vehicles used to transport explosives or detonators will be equipped with a fire extinguisher with a rating of not less than 10 BC units.
- All underground mobile equipment will carry a fire extinguisher with a rating of 5 BC units or higher.

The mobile fire fighting equipment that will be available for use in emergencies occurring during Modular Development Phase operations is listed below. (Additional equipment will be provided for the Commercial Phase.)

- One fire truck (1000-gpm pumper) equipped with foam equipment, as described above.
- One foam-concentrate storage trailer.

Equipment, normally used for operation, which will be available for fire fighting includes:

- Water trucks equipped with pump and fire hoses.
- Dozers and graders.
- Front-end loaders.

3.6 STOCKPILES

Stockpiles will be located at least 50 feet from all buildings and other facilities, and accessways (at least 12 feet wide) will be maintained around and between stockpiles to permit the approach of fire control equipment. Dozers, loaders and water trucks will be used to expose and extinguish fires occurring within stockpiles.

3.7 CRUSHERS, CONVEYORS AND BAGHOUSES

In locations where fire would create a hazard to personnel, belt conveyors will be provided with safety switches to stop the drive pulley automatically in the event of excessive slippage.

A fire extinguisher, rated at not less than 10 BC units, will be provided inside or within 25 feet of the operating stations of all crushers and conveyors and outside, but within 25 feet of, each baghouse.

3.8 OFFICES, WAREHOUSES AND SHOPS

Combustible materials, grease, lubricants or flammable liquids will not be allowed to accumulate in areas where they can create a fire hazard. All rubbish and combustible trash will be kept in metal containers. Oily and greasy rags will be kept in covered metal containers.

Smoking will be prohibited at or in the vicinity of operations constituting a fire hazard, and "No Smoking or Open Flame" signs will be conspicuously posted. A fire extinguisher, rated at not less than 2 A units, will be provided for each 3,000 square feet of protected building area. At least one fire extinguisher, rated at 2 A units, will be located near the stairway on each floor of multi-storied structures.

Electrical wiring and equipment for light, heat and power sources will be installed in compliance with provisions of the National Electrical Code.

3.9 FUEL STORAGE AND DISPENSING

At least one fire extinguisher, rated at not less than 20 B units, will be located outside but within 10 feet of the door of any room used for storage of more than 60 gallons of flammable liquids. At least one fire extinguisher, rated at not less than 20 B units, will be located not less than 25 feet nor more than 75 feet from outdoor storage area for flammable liquids.

Storage tanks containing flammable liquids will be separated. Spacing between adjacent tanks and between tanks and processing areas is described in Part 3.4A above. The storage area will be graded to divert possible spills away from buildings or work areas and will be surrounded by dikes, which will form spill-containment basins, as described in Part 3.4A above.

3.10 WELDING AND CUTTING OPERATIONS

Fire extinguishers, water hoses and other fire fighting equipment will be located conveniently so that they will be ready for use in case of fire. Employees doing welding will wear fire resistant gauntlet gloves and aprons of asbestos or leather, or equivalent material, as protection

against heat and sparks. No employee will leave a torch until the oxygen and acetylene valves have been completely shut off.

Whenever practicable, all arc welding and cutting operations will be shielded by non-combustible or flame-proof screens. When welding or cutting is such that normal fire precautions are not sufficient, additional personnel will be assigned to guard against fire. Welding or cutting will not be performed in atmospheres containing more than 1.0% of flammable gases.

Any container that has contained a toxic or flammable substance will either be filled with water or thoroughly cleaned of such substance, ventilated and tested before being welded, cut or heated.

Oxygen cylinders in storage will be separated from fuel-gas cylinders, reserve stocks of carbides, or highly combustible materials by a minimum distance of 20 feet or by a non-combustible barrier at least 5 feet high having a fire-resistance rating of at least 1/2 hour.

3.11 MANAGEMENT AND TRAINING

The objective of personnel training in the overall fire prevention and control plan is two-fold: 1) to provide instruction in safe procedures for normal operation of the facilities and in recognition and avoidance of potentially hazardous situations and 2) to provide instruction in the specifics of the fire protection plan and the use of fire fighting equipment.

A. Training - All personnel will receive basic training, as well as on-the-job training, and will be tested to determine the knowledge level attained. Written manuals will be issued to the operators of each process unit covering: normal procedures for startup, operation and shutdown; special procedures for emergency shutdown and preparation of equipment for maintenance; and safe practices. The "unit" manuals will

also provide detailed information on the process equipment controls. Line supervisors will be responsible for ensuring that operators perform in the approved safe manner. The plant engineering and technical section, as well as the plant safety group, will assist in ensuring that the supervisors understand and accept this responsibility.

Fire fighting training will be given to all personnel at regular intervals to maintain familiarity with fire fighting equipment use and fire fighting procedures. These training sessions will stress knowledge of the fire protection plan, which will detail procedures to be followed and assign duties to be performed by specific persons in case of a fire, major spill or other emergency. The detailed fire protection plan will include plot plans of processing units, indicating location of fire extinguishers, fire hydrants, foam connections and other equipment and facilities.

In-plant fire teams will be organized among personnel on duty for each shift. A call-out procedure will be used to obtain additional personnel, if required. Members of these fire teams will receive intensive continuous training in actual fire fighting techniques at the fire training area. Operating supervisors, who normally direct a fire attack, will be given special training by the plant fire chief in fire fighting techniques and strategy. This training will be supplemented by formal courses in fire fighting at accredited fire schools.

B. Emergency Procedures - A detailed fire control plan will be developed and implemented when final design is completed. Procedures will include those outlined in the plan, as well as the following:

- Emergency telephone numbers and notification procedures.
- Emergency communication procedures.
- List and location of fire-fighting equipment.
- Fire-alarm procedures and emergency evacuation plans.
- Arrangements for emergency first aid.

CHAPTER 4

NOISE CONTROL

CHAPTER 4
NOISE CONTROL

Construction and operation of the RBOSP mining, processing and disposal facilities will generate significant amounts of noise. Facilities will be designed and operated utilizing the best available technology to achieve compliance with applicable laws, standards and regulations.

4.1 REGULATIONS

Pertinent Federal and State of Colorado legislation concerning noise control has been reviewed, and project planning has been and will continue to be designed to ensure compliance. The principal legislation is:

- Noise Control Act of 1972 - Public Law 92-574.
- Environmental Protection Agency Regulations - 40 Code of Federal Regulations, Part 202, "Motor Carriers Engaged in Interstate Commerce".
- Section 25-12-101 through 108, 1973 Colorado Revised Statute "Noise Abatement".
- 30 CFR 57.5-50 Metal and non Metal Mine Health and Safety - Underground, MESA.
- 40 CFR Part 204 - Noise Emission Standard for Construction Equipment - Portable Standard, for Air Compressors (effective 1-1-78).

4.2 NOISE LEVELS

It is not possible to accurately predict the overall noise levels to be expected from large construction, processing and mining operations at

Tract C-a. However, due to the remote location, the general public will not be subjected to excessive noise levels.

Federal regulations stipulate that no employees shall be exposed to noise levels in excess of those listed in Table 6-4-1.

Table 6-4-1

MAXIMUM NOISE EXPOSURE*

Duration (hr/day)	Sound Level (db(A), slow response)
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

Note: No exposure shall exceed 115 db(A). Impact noises shall not exceed 140 db, peak sound pressure level.

*30 CFR 57.5-50

In addition, Section 25-12-101 through 108 (Noise Abatement) of the 1973 Colorado Revised Statutes lists the following maximum permissible noise levels for an industrial zone:

Noise-Level Permitted (db(A)	
7:00 am to next 7:00 pm	7:00 pm to next 7:00 am
80	75

During the baseline environmental data acquisition period, ambient sound levels were measured twice, once during each of the two summers. The 24 hour integrated average sound levels ranged between 34 and 54 db.

The principal sources of noise during these surveys were air movement in the local vegetation, intermittent bird sounds, and aircraft overflights. There was no site activity after dark and very little during the day near the four monitoring sites. The four sites were located near the four air quality monitoring sites which contributed a small amount of constant background noise from their air conditioner exhausts and air sampling pumps. There was a difference of about 10db between the two summer surveys. This was attributed to a difference in average wind speeds during the survey periods.

The Modular Development Phase will bring several significant noise sources into operation. The most intense is expected to be a compression system for retort combustion gases. The mine ventilation exhaust fans and the operation of a boiler and waste gas thermal oxidizer will also create noise. Additional noise will be created by vehicle traffic, infrequent impulse noise due to blasting (3 times a day) during retort preparation, etc.

The gradual expansion of operations into the Commercial Phase will take some years. The presently envisioned compressor capacity will be increased ten fold during the Commercial Phase. The Commercial Phase will entail the conveyor transport of raw and processed shale, the operation of surface retorts, additional mine ventilation fans, and the operation of a multi-turbine unit electric power plant.

4.3 CONTROL METHODS

Much of the machinery used in crushing the oil shale in preparation for retorting will be enclosed to facilitate dust control. These enclosures will serve a second function by providing sound attenuation.

Mobile machinery will be equipped with customary exhaust controls to limit the noise emanating from these sources.

All motor carriers engaged in interstate commerce and under the control of this project will be equipped with adequate mufflers, properly designed tires and other equipment required to meet the limits established by law (86 db(A) up to 35 mph and 90 db(A) over 35 mph).

Large compressors and gas turbines will be equipped with sound control devices and, when practicable, will be enclosed in sound control structures.

Noise exposure of workmen will be controlled by the following techniques if sound levels of any of the machinery or operations exceed the allowable standards:

- Providing sound-control enclosures.
- Providing individual protective equipment.
- Limiting exposure time.

4.4 NOISE MONITORING

Regulations for the control of noise are oriented toward the protection of exposed personnel. There is little literature on the impact of noise on ecological systems. Ambient noise levels to which personnel may be exposed during the work day will be measured semi-annually or whenever a new or potentially significant different noise source is installed or put into operation. These surveys will be made primarily for the protection of personnel and will be made in accordance with American National Standards Institute Standard S1-41971. Such measurements will be made during periods of low wind noise interference (speed less than 5 mph) in accordance with Section 25-12-103.

The semi-annual ambient sound level measurements will be continued into the Commercial Phase until such time as a constant level of activity is achieved. Following this, the noise monitoring program will be oriented completely toward occupational safety.

CHAPTER 5

AIR QUALITY CONTROL

CHAPTER 5
AIR QUALITY CONTROL

The Rio Blanco Oil Shale Project recognizes that preservation of the air quality of the Piceance Basin is of utmost importance. Every reasonable effort will be made to control fugitive dust, to minimize particulate and gaseous emissions and to maintain air pollutants at levels within State and Federal standards. The best available control technology will be used. Soil stabilizers, dust retardants, surfactants, modern suppression systems, dry-fabric collection designs and high-efficiency wet scrubbers will be employed to maintain the air quality of the Tract C-a area within standards. Terms used in this discussion are defined under 5.9 of this chapter.

5.1 CONSTRUCTION

A. Roads - The soil in the Piceance Basin is light and disintegrates into a fine powder when disturbed by heavy traffic during the dry seasons of the year. Proper abatement and preventive measures will be required to prevent fugitive dust from unpaved roads and trails in the Tract C-a vicinity during initial construction activities.

Traffic will be confined to specified roads, corridors and designated construction areas to minimize land disturbance. The use of off-road vehicles will be restricted to necessary areas of the construction sites.

During construction, trails, roads and parking areas will be watered frequently by trucks and/or sprinkler systems to allay fugitive dust. Dust palliatives, such as a polymer solution, latex solution or asphalt emulsion, will be used as required to prevent the soil from becoming airborne. Unpaved road surfaces and parking lots may be treated with penetration chemicals, such as lignin sulfonate.

Since haul roads will not be paved, continual use of water and soil stabilizing agents will aid in controlling dust and provide a surface that will minimize tire wear. Salt and sand may be required during freezing conditions.

B. Mine Site - Fugitive dust abatement and preventive procedures will be conducted on a continuing basis during development of the mine shafts, compressor station and conveyor routes. Prewatering and wetting with sprinklers and water trucks will aid in controlling fugitive dust during initial mining activities. Frequent watering and sprinkling will be provided to control the dust during the heavy construction activities involved in developing the sites.

Treating with dust palliatives will help control fugitive dust generation during construction and mining activities. Routing, speed control and closure of construction areas to extraneous traffic will reduce the total dust load in the airshed.

To aid in dust control, construction vehicle activity will be restricted to the actual construction sites and access roads. A coordinated effort to minimize land disturbance will reduce the windblown dust problems.

Straw, matting and mulch from existing vegetation will be used if necessary to hold the soil until revegetation takes place. High winds, which could aggravate the airshed particulate loading, may occur during late summer thunderstorm activity. Extra sprinkling and watering may be required during these times.

C. Processing Facility - Restricting the activity of off-road vehicles and construction equipment to the construction sites will reduce land disturbance and minimize damage to the vegetative cover around the process facility. The coordinated delivery of construction materials and machinery to designated storage areas will also reduce traffic and land disturbance.

During construction of the processing facility, continual dust control procedures will be employed. The site access aisles will be watered frequently to control fugitive dust around work areas. Sprinkler systems can be used to wet large storage areas, dikes and excavations.

Compaction, with the possible use of dust palliatives and retardants, will hold the soil until paving, revegetation or other permanent cover is in place. The processing facilities and access aisles will be paved or covered with gravel as soon as the construction activities permit. Landscaping and revegetation necessary to hold the soil and control fugitive dust will be accomplished as construction of major portions of the processing facility is completed.

D. Processed Shale Disposal Area - A portion of the site selected for processed shale disposal will be stripped of soil at the start of the Commercial Phase to facilitate disposal operations. The topsoil will be stockpiled for use during the reclamation activities. Fugitive dust control methods for processed shale site development will be the same as those used for road construction activities.

E. Development Ore Disposal Piles and Soil Stockpiles - Fugitive dust control techniques will be utilized during the building of the development ore disposal piles and the soil stockpiles. Retardants and revegetation practices will be used to control the dust on the stockpiles and disposal piles. A lowering tube will be used to minimize dust generation at the primary crushed ore stockpile, and a telescopic spout will be used at the reserve storage facility.

F. Support Facilities - The dust control procedures for construction of the support facilities will be the same as those used in other areas. The important techniques of dust control include minimizing land disturbance, watering and paving roads, sprinkling large disturbed areas and enclosing or shielding dusty work places. Palliatives, retardants, soil stabilizers, mulching, matting and revegetation will be employed as the dust control situation demands.

G. Burning Control - Open burning of waste, timber, brush or construction debris will be used only as a last resort and must be authorized by the Area Oil Shale Supervisor. A permit must also be obtained from the Colorado Department of Health, Air Pollution Control Division. Control of burning is detailed in Chapter 3 of this section.

H. Construction Vehicles and Equipment - All gasoline and diesel powered equipment will comply with applicable emission regulations. Proper routine maintenance procedures for this equipment will be employed to reduce emissions.

5.2 MINING

A. Modular Development Phase (MDP) - The primary effect of the mining operation on air quality is via the exhaust ventilation system. All of the diesel exhaust, powder smoke and particulates generated in underground mining enter the ventilation exhaust air stream. The MDP ventilation system will discharge up to 200,000 SCFM of air. This will be discharged through the MDP exhaust ventilation shaft. See Figure 6-5-1.

Concentrations of several substances in the air stream may at times approach the maximum allowable under Colorado Mining Regulations. These are as follows:

Carbon Monoxide	50 ppm
NO_x	25 ppm
Particulate Carbon	10 million particles/ft.^{3}
Other Particulates	2 million particles/ft.^{3}

In addition to the above, sulfur oxides from underground diesel fuel consumption are calculated to be insignificant.

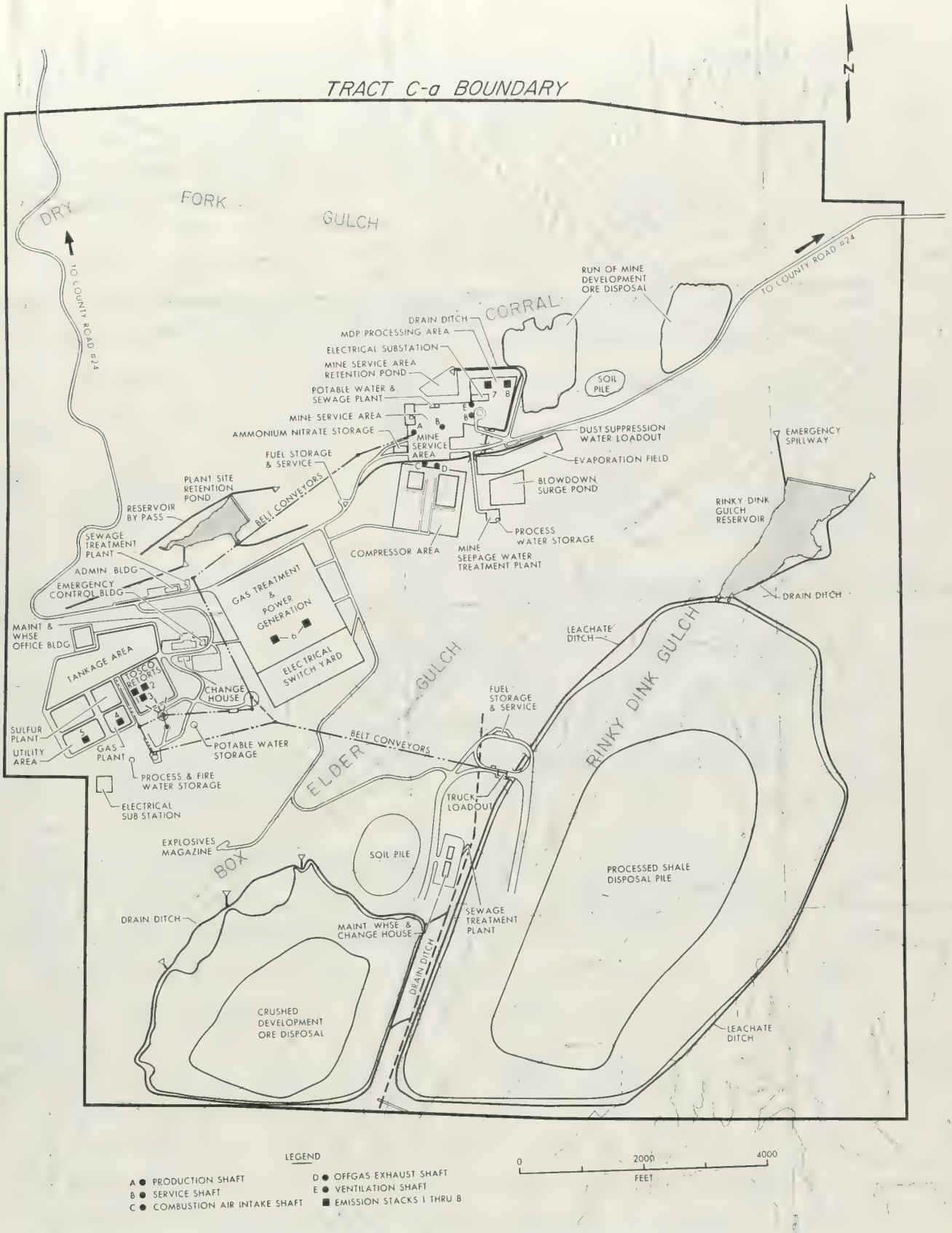


Figure 6-5-1
SITE PLAN

B. Commercial Phase - Total ventilation exhaust air for the Commercial Phase will be 4,000,000 SCFM. Maximum concentrations of pollutants of this air stream will be the same as given for the MDP except that 3.7 pounds per hour of sulfur oxides, from underground diesel fuel consumption, will be present. Plans for the location of the exhaust ventilation shaft are shown in Figure 6-5-1.

An underground primary crusher is planned for the Commercial Phase. The crusher will have a separate dust collection system which will discharge cleaned air into the exhaust ventilation air at a point downstream of any workings.

5.3 DEVELOPMENT ORE HANDLING

A. Modular Development Phase - Large receiving bins will be constructed at the tipple of the production shaft to receive run-of-mine (ROM) development ore excavated from the mine shafts and drifts as the Modified In Situ retorts are developed. During the MDP, these tipple bins will be used to load 35-ton haul trucks which will transport ROM ore to disposal sites east of the mine service facilities. Disposal sites are discussed in Section 4, Chapter 3.

1. Dust Suppression System - Dust suppression will be used during the filling of the receiving bin and truck load-out operation. The dust suppression system will cause small dust particles to agglomerate. With suppression, the bin or truck load-out equipment will not be considered a source of particulate emission.

2. Vehicular Dust Control - The haul truck and service vehicle dust emission estimates for ore hauling and disposal for the MDP are listed in Table 6-5-1. The haul roads and disposal areas will be graded and treated to maintain a suitable surface for the heavy haul trucks. The haul road surface must be somewhat pliable and contain the required amount of fine material to minimize tire wear. This fine material will

be kept wet by sprinkling or treated with a palliative to control dust emissions. The various palliatives that may be used to augment the watering program are asphalt emulsions, polymer solutions, salt solutions and lignin sulfonate. Final choice of the palliative used will be subject to AOSS approval.

Table 6-5-1

MODULAR DEVELOPMENT PHASE
ROM DEVELOPMENT ORE DISPOSAL EMISSION ESTIMATES

	Vehicle Type	No.	Vehicle Miles/Hr. (Fleet)	Emissions Factor Lbs/Veh-Mile	Est. Emission Lb/Hr.
1.	35-ton trucks	3	38	0.09	3.42
2.	Bull dozer	1	5	0.01	0.05
3.	Pick-up	1	11	0.09	0.99
4.	Water truck	1	10	0.09	0.90
	Total Estimated Vehicle Emissions				5.36

3. Ore Disposal Dust Control - ROM ore will be dumped, spread and compacted to form a stable fill. Water will be applied by water truck or by sprinkling to aid in compaction and to quell the dust. When the disposal area has been filled to the desired height, dust retardants will be sprayed on the top and sides of the pile.

Soil will be added and revegetation practices will be used to reduce fugitive dust generation from the disposal pile. Refer to Section 6, Chapter 8, for a discussion of revegetation techniques.

B. Commercial Phase - In 1985, a primary crusher will be installed underground to reduce the ROM ore to a minus 8-inch size. The crushed development ore will be elevated to the surface, received in tipple bins and conveyed to a waste ore disposal area.

During the two years before the TOSCO II retorts are operational, the primary crushed ore will be conveyed to a disposal pile in the southern

portion of the tract as shown on the Site Plan (Figure 6-5-1) and retained for coarse material cover on the final processed shale disposal pile. Conveyors are discussed in Section 3, Chapter 3.

1. Ore Handling Dust Control - The crushed development ore will be damp when it is mined. Dust suppression techniques will be used at the tipple bin and feeders to enhance the moist condition of the ore and thereby prevent dust emission. Covers, hoods and dust suppression systems will be used to control fugitive dust along the conveyors.

The return belt will be cleaned with a brushing unit or belt scraper to prevent the accumulation of material along the ground.

Dust suppression sprays will be used on the disposal area truck load-out equipment. Hoods and wind breaks will contain any dust generated during the truck loading operation.

With suppression, the conveyor transfer points or bin feeders will not be considered a source of particulate emission. If dust collectors or scrubbers were to be used, their stack or vent would be considered an emission point and the collected dust would require disposal.

2. Crushed Development Ore Disposal Dust Control - The same dust control techniques will be applied to the crushed development ore disposal operation as were used during the Modular Development Phase ROM development ore handling and disposal. The haul roads, ramps and ore disposal pile will be watered, treated with retardants and sprinkled to allay the generation of fugitive dust during this period. Haul truck and service vehicle dust emission estimates for crushed development ore disposal are summarized in Table 6-5-2.

Table 6-5-2

CRUSHED DEVELOPMENT ORE DISPOSAL
EMISSION ESTIMATES

	Vehicle Type	No.	Vehicle Miles/Hr. (Fleet)	Emissions Factor Lbs/Veh-Mile	Est. Emission Lb/Hr.
1.	Rear dump trucks	7	91	0.09	8.19
2.	Bull dozers	2	8.6	0.01	0.09
3.	Water truck	1	7.5	0.09	0.68
4.	Service vehicles	2	16	0.09	1.44
	Total Estimated Vehicle Emissions				10.40

5.4 RETORT FEEDSTOCK PREPARATION

The retort feedstock preparation operation begins in 1987 when the TOSCO II retorts are complete. This operation is expected to generate a major portion of the dust and particulate emissions that will result from oil shale processing. The emission sources, quantitites of dust generated and methods of control are summarized in Table 6-5-3.

Estimates of emissions and control efficiencies for conveying, crushing, and screening are based on information from: confidential reports from TOSCO; equipment vendor's data; Oil Shale Air Pollution Control, EPA - 600/2/75-009, May 1975; and An Environmental Impact Analysis for a Shale Oil Complex at Parachute Creek, Colorado, Colony Development Operation, Volume 1, 1974.

A. Stockpiling of Primary Crushed Ore - Primary crushed ore will be conveyed to the primary stockpile. The primary ore stockpile will be built by employing a concrete tower 114 feet high and 12-foot inside diameter with rectangular openings at multiple levels. The tower will keep the material stream enclosed and prevent the wind from blowing fine ore particles as they drop from the conveyor belt. A collection system will be installed atop the tower to provide dust control for the

Table 6-5-3

COMMERCIAL PHASE MATERIAL HANDLING

EMISSION ESTIMATES

OPERATION	NOMINAL TPH	EMISSION FACTOR (%)	EST. EMISSIONS W/O CONTROL (LB/HR)	CONTROL METHOD	CONTROL EFFICIENCY (%)	EST. EMISSIONS W/CONTROL (LB/HR)
Transfer at Tipple	1949	.01	390	Suppression	99.95	0.19
Overland Conveyor Transfer points[3]	1949 ea	.002	78 ea	Suppression	99.95	0.04 ea
Primary Crushed Ore Stockpile	1949	.005	195	Suppression	99.0	1.95
Primary Crushed Ore Reclaim	1867	.01	373	Baghouse	99.8	0.75
Reclaim Transfer Point	1867	.002	75	Baghouse	99.8	0.15
Secondary Crushed & Screening Building Transfer Point[2]	2879 ea	.002	115 ea	Baghouse	99.8	0.23
Feeders	1867	.01	373	Baghouse	99.8	0.75
Screens	2879	.05	2879	Baghouse	99.8	5.76
Impact Crushers	2655	.15	7965	Baghouse	99.8	15.93
Screen Transfer Points	1867	.002	75	Baghouse	99.8	0.15
Feedstock Storage Bin Supply Transfer Point	1867	.002	75	Baghouse	99.8	0.15
Reserve Storage Transfer Points[2]	1867 ea	.002	75 ea	Baghouse	99.8	0.15 ea
Reserve Storage	1867	.06	2240	Suppression	99.95	1.12
Reserve Storage Reclaim	1867	.01	373	Baghouse	99.8	0.75
Feedstock Storage Bin Reclaim Transfer Points	1500	.01	300	Baghouse	99.8	0.60
Feedstock Storage Bin Emergency Transfer Points[2]	500	.01	100	Baghouse	99.8	0.20
Retort Receiving Bins	1500	.002	60	Baghouse	99.8	0.12
Processed Shale Conveyor Transfer Points	1447	0	0	Suppression	99.95	0.00
Processed Shale Truck Loading	1447	0	0	Suppression	99.95	0.00

Est. Emissions w/o Control (lb/hr) = TPH x 2000 lb/ton x Emission Factor

Est. Emissions w/Control (lb/hr = Est. Emissions e/o Control x [100.00 - Control Eff.]

conveyor discharge and the tower. A slight negative pressure will be maintained within the tower to contain the dust as the rock leaves the openings.

By extending the stockpile with bulldozers, a 300,000-ton capacity will be attainable. Sprinkling and dust retardants will be used to control fugitive dust during the expanded pile development and mobile reclaiming operations.

Dust production is estimated at 0.01% of the material deposited. An overall dust control efficiency of only 99% is assumed because of the exposed stockpile area. Water sprays will be applied to the open pile if it becomes necessary.

B. Reclaiming from Primary Crushed Ore Stockpile - The reclaiming equipment will generate dust in the range of 0.002% of the oil shale handled.

The dust-laden air will be drawn through a centralized dust collection system and a baghouse will provide the required dust control. The collected dust will be slurried to the processed shale moisturizer.

C. Secondary Crushing and Screening - The secondary crushing and screening facility will consist of multiple systems contained in the same building complex. Baghouses will collect the dust from the facility and the collected dust will be slurried to the processed shale moisturizer. Hoods, enclosures and rubber curtains will help minimize dust emission from the equipment. The crusher building will be maintained under a slight negative pressure to contain the dust.

The dust generated by the secondary crushing and screening facility is estimated to be 0.22% of the oil shale processed. The production rate for the secondary crusher operation will depend on retort feed requirements.

D. Feedstock Storage - The sized ore from the secondary crushing facility will be conveyed to the feedstock storage bin or to an emergency open stockpile. One storage silo with three reclaiming systems will be used for the TOSCO II retort feed storage. The open stockpile will be used only for upset conditions and testing purposes. If necessary, the open stockpile will be sprayed with a polymer or latex retardant solution which will form a thin crust and prevent erosion by wind or water.

Since the moisture content of the minus 3/8-inch oil shale will be low, the feedstock storage bin will have a dry dust collection system. The dust generated by filling and reclaiming of the bin is estimated to be 0.07% of the fine ore feedstock handled. A conventional silo or storage bin dust collection system will be used. A baghouse will be used on the inlet and discharge points of the bin for dry collection of the dust. The collected dust will be slurried to the processed shale moisturizer.

E. Alternative Dust Control Techniques - An alternative to a dry collection baghouse system is a wet scrubber. Control efficiencies greater than 99.8% could be expected from this device. However, wet scrubbers require large quantities of water and a system to remove the resulting slurry. Freezing conditions during the winter would reduce the collection efficiency due to ice build-up. Present concern to minimize water consumption and uncertainty about cold weather operations precludes the use of the wet scrubber on the crushing, screening and conveying systems at this time.

An alternative dust control method around stockpiles is spraying with dust-retardant solutions. However, when the stockpile surface is disturbed or more ore is deposited, additional applications of the retardant would be required.

F. Table of Estimated Feedstock Preparation Particulate Emissions - The estimated combined particulate emissions, gas flow rate, temperature, stack heights and diameters for material handling are presented in Table 6-5-4. The estimated emissions with control are compared with the

maximum rate allowed by the Colorado process weight regulation (Colorado Air Pollution Control Commission, Regulation No. 1).

Table 6-5-4

COMMERCIAL PHASE FEEDSTOCK PREPARATION
EMISSION ESTIMATES

	Primary Stockpiling	Primary Ore Reclaiming	Retort Feedstock Preparation Plant	Feedstock Storage
Material Handled (TPH)	1949	1867	1867	1867
No. of Stacks	1	1	2	1
Stack Height (ft.) from Grade	135	135	135	135
Stack Diameter (ft.)	4.5	3.0	9.0	4.0
Gas Flow Rate (ACFM)	6,000	6,000	136,000	12,000
Exit Temperature (^{o}F)	Ambient + 4	Ambient + 4	Ambient + 4	Ambient + 4
Control Device	Suppression	Baghouse	Baghouse	Baghouse
Control Device Efficiency (%)	99.0	99.8	99.8	99.8
Estimated Emissions with Control (PPH)	1.95	0.75	23.05	0.15
Colorado Weight Rate Emission Limit (PPH)	58.17	57.77	57.77	57.77

5.5 PROCESSING

The Air Quality Control Plan for the MDP and Commercial Phase processing facilities involves aspects of plant design, operation and maintenance. The plant design is oriented toward control of emissions of sulfur dioxide, nitrogen oxides, trace hydrocarbons, and particulate matter to the atmosphere. Systems included in the processing facilities for this purpose are described in Section 3 and are reviewed below specifically for those aspects relating to air quality control. Section 3, Chapters 2 and 3 also discuss processing emissions and their control. Guidelines for operation and maintenance have been developed to insure proper performance of these control systems.

A. Modular Development Phase

1. Plant Design - The processing facility is designed to control atmospheric emissions from thermal oxidizer and steam boiler stacks. Gas produced from MIS retorts is scrubbed with water to remove particulates and hydrocarbon mist. The scrubbed gas is burned in a thermal oxidizer and the resulting flue gas is scrubbed with an alkaline solution to remove about 90% of the sulfur dioxide formed during combustion. The steam boiler is fired with low sulfur fuel oil.

Estimated emissions from the thermal oxidizer and steam boiler stacks during the operation of a commercial size MIS retort are presented in Table 6-5-5 (see Figure 6-5-1 for stack locations). Emissions from the smaller MIS retorts operated in the early stages of the Modular Development Phase will be less than the estimates shown in Table 6-5-5. Emission standards applicable to the processing facilities are found in Colorado Air Quality Regulations 1 and 6 and in the EPA New Source Performance Standards. Emission estimates are within these standards.

Hydrocarbon emissions from storage tanks in the Modular Development Phase processing facility are presented in Table 6-5-6. Oils stored during this phase have low vapor pressures and are stored in cone roof tanks.

2. Operation and Maintenance - The following basic guidelines will be used for operation and maintenance of the air quality control systems in the processing facility:

- Detailed operating manuals will be prepared giving proper procedures for startup, operation and shutdown of equipment. Operators will receive basic and on-the-job instruction in these procedures.
- Instrumentation required for process control and measurement, such as temperature, pressure and flow rate indicators, recorders, and controllers, will be provided. Analytical

Table 6-5-5

MODULAR DEVELOPMENT PHASE
PROCESSING FACILITY ESTIMATED STACK EMISSION DATA
COMMERCIAL SIZE MIS RETORT OPERATION

Stack Description	Thermal Oxidizer	Steam Boiler
Stack Location No.	7	8
Stack Height, Ft.(1)	330	330
Stack Diameter, Ft.	21	7'-6"
Stack Gas Parameters		
Gas Flow, LB/HR	1,828,000	206,700
ACFM	644,400	129,800
Molecular Weight	27.2	29.1
Exit Temperature, ^{o}F	450	700
Moisture, Vol. %	32.8	10.7
SO_2 Content		
LB/HR	371	62
PPM (Vol.)	87	136
LB/MMBTU	0.39	0.28
NO_x Content		
LB/HR	831	62.1
PPM (Vol.)		190
LB/MMBTU Fired	0.89	0.28
Particulates		
LB/HR	42	32.8
gr/ACF	0.0056	0.03
Hydrocarbons		
LB/HR	2.3	5.2
Fired Duty, MMBTU/HR	937	226

(1)Measured from grade (6925 feet elevation)

equipment will be available for periodic measurement of the flow and composition of stack gases.

- Periodic inspection and maintenance of equipment and instrumentation will be scheduled to insure proper performance of the systems in accordance with design.

Table 6-5-6

MODULAR DEVELOPMENT PHASE
PROCESSING FACILITY ESTIMATED TANK VAPOR LOSSES

Tank Description	Raw Oil Storage	Fuel Oil Storage
Tank Service	Raw Shale Oil	Fuel Oil
Tank Data		
Number	1	1
Dimensions, ft.	80Ø x 56	30Ø x 40
Capacity, BBL each	50,000	5,000
Type	Cone Roof	Cone Roof
Storage Temp ^{o}F	80	55
Avg. Outage, %	50	50
Annual Turnovers	27.5	71.4
Vapor Pressure of Contents, psia	0.025	0.004
Tank Vapor Losses, BBL/yr	68	1

B. Commercial Phase

1. Plant Design - The design philosophy with regard to air quality control is essentially the same as that used for the MDP processing facility. Higher capacity and increased complexity of Commercial Phase processing, however, require more extensive use of control systems.

Fuel for the processing facility is supplied by purified high BTU gas produced by TOSCO II retorting and low BTU gas produced by MIS retorting. High BTU gas is contacted with water in the raw oil recovery and high

BTU gas plants where about 99% of the ammonia, which can form nitrogen oxides in combustion systems, is removed. Gas from the gas plant is desulfurized by scrubbing with Sulfinol solution to remove about 98% of the sulfur compounds contained in the untreated gas.

Gas from MIS retorting is first scrubbed with water in a venturi scrubber to remove entrained shale dust and then compressed to condense hydrocarbon vapors, water, and about 90% of the ammonia contained in the gas. About 10,000 BSD of light shale oil is removed from the gas stream. This oil contains about 1800 pounds per hour of equivalent SO_2 if allowed to remain in the gas stream prior to combustion of the low BTU gas. The compressed gas is then treated to remove hydrogen sulfide and carbonyl sulfide. The overall removal of sulfur compounds and ammonia from the MIS gas is about 98% and 90%, respectively.

Estimated emissions from the Commercial Phase processing facility are presented in Table 6-5-7. The important process stacks are located in the TOSCO II retorting plant and in the power generation plant (see Figure 6-5-1). The preheat systems of the TOSCO II plant are fired by purified high BTU gas and low BTU gas. Flue gases from the preheating systems are scrubbed in high energy venturi scrubbers prior to release to the atmosphere. Caustic is injected into the wet scrubbers to remove sulfur dioxide from the flue gases down to an expected concentration of 10 ppmv. The TOSCO II preheat system contains an incinerator to remove 90 - 95% of the hydrocarbon vapors contained in the flue gas.

Flue gases from the ball circulation and shale moisturizing systems of the TOSCO II plant are also scrubbed in high energy venturi scrubbers before release to the atmosphere. Entrained shale dust is also removed from the flue gases in these scrubbers.

Control of emissions from the power generation plant stacks is accomplished by the use of purified fuel gas prepared from raw gas produced by the MIS retorting operations.

Table 6-5-7

COMMERCIAL PHASE PROCESSING FACILITY
ESTIMATED STACK EMISSION DATA
----------TOSCO II----------

Stack Description	Preheat System	Steam Superheater-Ball Circ.	Shale Moisturizing	High BTU Gas Plant Reboiler	Thermal Oxidizer	Power Generation Plant
Stack Location No.	1	2	3	4	5	6
No. of Stacks	3	3	3	1	1	2
Stack Height, Ft. (1)	330	330	330	150	150	330
Stack Diameter, Ft.	12.0	6.0	3.0	3	9.5	35
Stack Gas Parameters						
Gas Flow						
LB/HR	1,815,000	384,000	212,000	20,700	280,000	10,000,000
ACFM	603,000	156,000	111,300	13,800	128,000	4,450,000
Molecular Weight	27.7	25.6	19.9	28.2	22.	30.5
Exit Temperature, ^{o}F	122	200	200	730	180	400
Moisture Content, Vol%	16	31	83	14	66	5
SO_2 Content						
LB/HR	42	0.6	-	0.3	31	384
PPM (Vol)	10	2.3	-	3	38	18
LB/MMBTU fired	0.046	0.015	-	.007	1.1	0.12
NO_x Content						
LB/HR	429	21	-	8	50	1,860
PPM (Vol)	143	30	-	225	85	123
LB/MMBTU fired	0.47	0.54	-	0.35	1.9	0.57
Particulates						
LB/HR	120	21	10	0.3	0.7	320
Grains/ACF	0.023	0.016	0.031	0.003	.006	0.1
Hydrocarbons						
LB/HR	147	-	-	0.6	0.7	20
Firing Duty, MMBTU/HR	307	13	-	22	27	3,260

(1) Measured from grade at TOSCO Retorting Plant
Note: Carbon monoxide content in stack gases is negligible

Water recovered from the processing operations is stripped with steam to remove dissolved hydrogen sulfide and ammonia. Gas from the stripping operation is sent to the sulfur recovery plant where hydrogen sulfide is converted to elemental sulfur and most of the ammonia is converted to molecular nitrogen.

Table 6-5-7 indicates compliance with all Colorado particulates and sulfur dioxide emission standards. The approximate hydrogen sulfide concentration in the Commercial Phase fuel gases is 10 ppmv for both purified MIS gas and purified high BTU gas. The limit imposed by Colorado Regulation 6 is 150 ppmv of hydrogen sulfide.

Hydrocarbon emissions from oil storage tanks in the Commercial Phase processing facility are controlled by using floating roof tanks for the more volatile liquids. Estimates of storage tank emissions are given in Table 6-5-8.

2. Operation and Maintenance - The basic guidelines established in the MDP for the operation and maintenance of air quality control systems will be followed in the Commercial Phase. Operating manuals will be prepared and operator training will be carried out for control systems not previously used in the Modular Development Phase.

5.6 PROCESSED SHALE DISPOSAL AND SUPPORT FACILITIES

The processed shale disposal activities will begin in 1987 when the TOSCO II retorts are operational. The moisturized processed shale will be conveyed from the plant site to the disposal pile in the southeastern portion of the tract.

Large (150-ton) haul trucks or scrapers will be used to transport the processed shale from the load-out hopper to the disposal area. The processed shale will be deposited and compacted to form a stable disposal pile. Water will be applied by water truck or by sprinkling as

Table 6-5-8

COMMERCIAL PHASE PROCESSING FACILITY
ESTIMATED TANK VAPOR LOSSES

Tank Description	MIS Oil Storage	Naphtha Storage	Heavy Oil Storage	Gas Oil Storage	Fuel Oil Storage	Fuel Oil Day Tank
Tank Service	Raw Oil	Naphtha	Heavy Oil	Gas Oil	Fuel Oil	Fuel Oil
Tank Data						
Number	1	1	2	1	1	1
Dimensions, ft	80Ø x 56	90Ø x 64	120Ø x 60	18Ø x 24	50Ø x 60	18Ø x 24
Capacity, BBL each	50,000	70,000	120,000	1,000	20,000	1,000
Type	Cone Roof	Floating Roof	Cone Roof	Cone Roof	Cone Roof	Cone Roof
Storage Temp ^{o}F	55	55	200	55	55	55
Avg. Outage, %	50	50	50	50	50	50
Annual Turnovers	365	18	73	1	18	365
Vapor Pressure of Contents, psia	0.01	2.2	0.01	0.01	0.02	0.02
Tank Vapor Losses, BBL/Yr						
Each	65	67	11	7	11	2
Total	65	67	22	7	11	2

the pile is built. Refer to Section 4 for a more complete description of the processed shale disposal operation.

A. Processed Shale Dust Control - The amount of dust generated by processed shale handling will be dependent in large part on the moisture content. It is planned that the processed shale will be kept at a moisture content of 11% to 19%. Therefore, little dust is expected during handling and compaction.

Dust control measures for the processed shale conveying and truck loading will consist of conveyor covers, hoods and suppression systems at transfer and discharge points. Maintaining the proper moisture content of the processed shale during the various handling steps is paramount. Estimates of fugitive dust associated with this operation are summarized in Table 6-5-9.

Table 6-5-9

PROCESSED SHALE DISPOSAL EMISSION ESTIMATES

Vehicle Type	No.	Vehicle-Miles Per Hour (Fleet)	Emission Factor Lbs/Veh-Mile	Estimated Emissions Lb/Hr
Bottom Dump Trucks	6	36	0.09	3.24
Scrapers, Disposal	3	12	0.04	0.48
Scrapers, Soil Handling	3	8	0.04	0.32
Dozers, Disposal	2	7.5	0.01	0.08
Dozers, Soil Handling	1	3.8	0.01	0.04
Compactors	2	10	0.01	0.10
Pick-Ups	6	48	0.09	4.32
Service Vehicles	6	12	0.09	1.08
Water Trucks	2	15	0.09	1.35
Total Estimated Vehicle Emissions				11.01

B. Disposal Pile Fugitive Dust Control - The haul roads, ramps and disposal pile lifts will be watered to control the dust while the processed shale is being placed and compacted. The water causes a cementing action which forms a natural crust. This crust will prevent the processed shale from becoming airborne if it is not disturbed by mechanical manipulation. Closure of inactive disposal areas from extraneous traffic will prevent the crust from being disturbed. As the processed shale disposal pile reaches its crest, it will be covered with a layer of coarse material and a layer of soil. The pile will then be revegetated.

C. Support Facilities - The fugitive dust and particulate emission control techniques for the construction of support facilities will be similar to those described earlier for the construction of the mine, processing facility and disposal sites.

The support facilities will include all office buildings, shops, water control dams, water diversion ditches, water reinjection systems, potable water supply, oil and sewage pipelines, electric transmission lines and power distribution facilities. Minimizing land disturbance, frequent watering and prompt revegetation are the key techniques for dust control for all phases of the oil shale project.

5.7 MODELING

Modeling of gaseous pollutants and salt drift was done to estimate potential impacts of the project on ambient air quality. Dispersion modeling of various gaseous pollutants was used to aid in the development of an engineering design which will meet ambient air quality standards. The dispersion model calculations were based on inversion intensities and depths describing worst case conditions. In addition, fumigation conditions were simulated to determine if they would cause worst case short-term air quality impacts. Deposition of salt resulting from the cooling tower drift was modeled to provide information for assessment of the effects of salt drift on local biota.

A. Dispersion Modeling - Dispersion modeling studies were done to verify that Federal and State ambient air quality standards can be met using best available control technology. The physical processes influencing the dispersion potential of the atmosphere over Tract C-a are discussed below. Applicable ambient air quality standards (legally enforceable concentration limits) are presented to enable interpretation and evaluation of project activities using the modeling results. Estimates of project emission sources modeled were summarized previously in this chapter. The actual dispersion modeling methodology, along with a discussion of its accuracy and applicability, is presented here. Conservative estimates were favored in developing the model. Finally, actual modeling results and interpretations are described.

1. Dispersion Meteorology Summary - The on-site meteorological data for the period of September 1, 1975 - August 31, 1976 were used as the baseline for air quality dispersion modeling. This data period was selected considering the relative completeness of the record.

Annual wind direction distributions and average wind speed data are summarized in Figures 6-5-2 through 6-5-7. These annual average data indicate a reasonable degree of consistency between levels and locations. In general, wind speeds are at a maximum during the day and at a minimum during

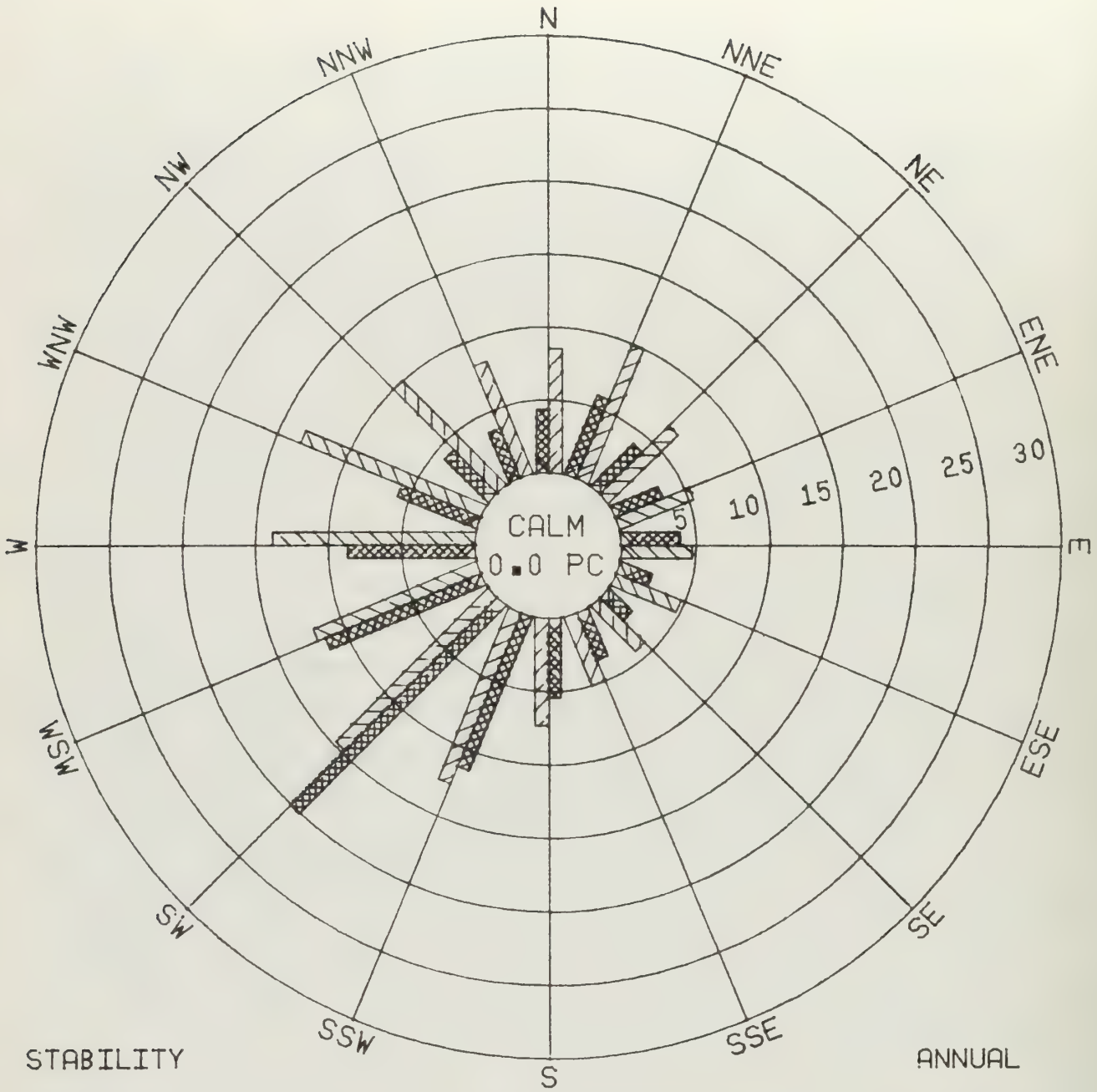
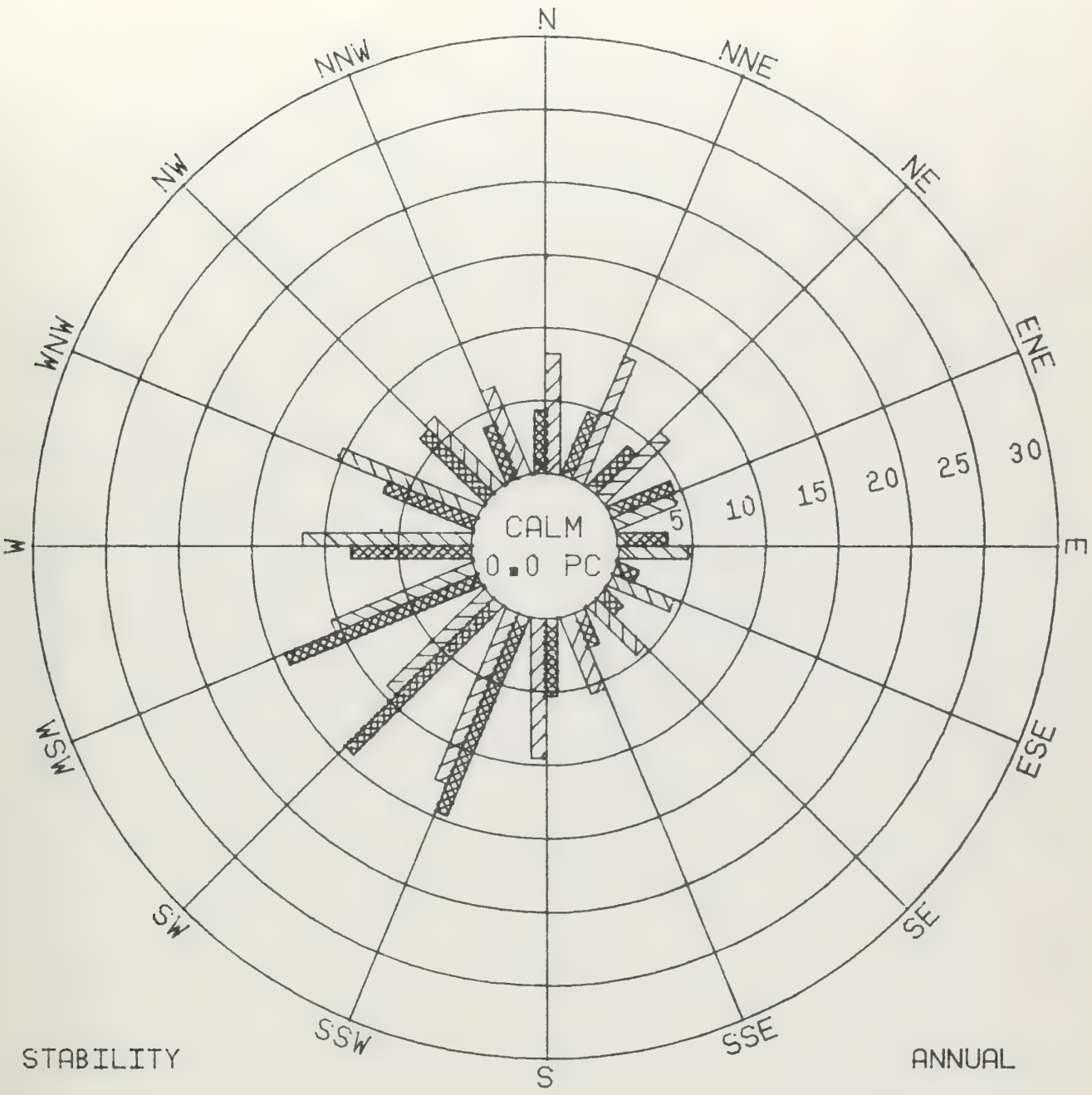


Figure 6-5-2

ANNUAL WIND ROSE, SITE 1 - 60 METERS



RIO BLANCO 9-1-75 TO 8-31-76
TOWER 1 30 METERS

Figure 6-5-3

ANNUAL WIND ROSE, SITE 1 - 30 METERS

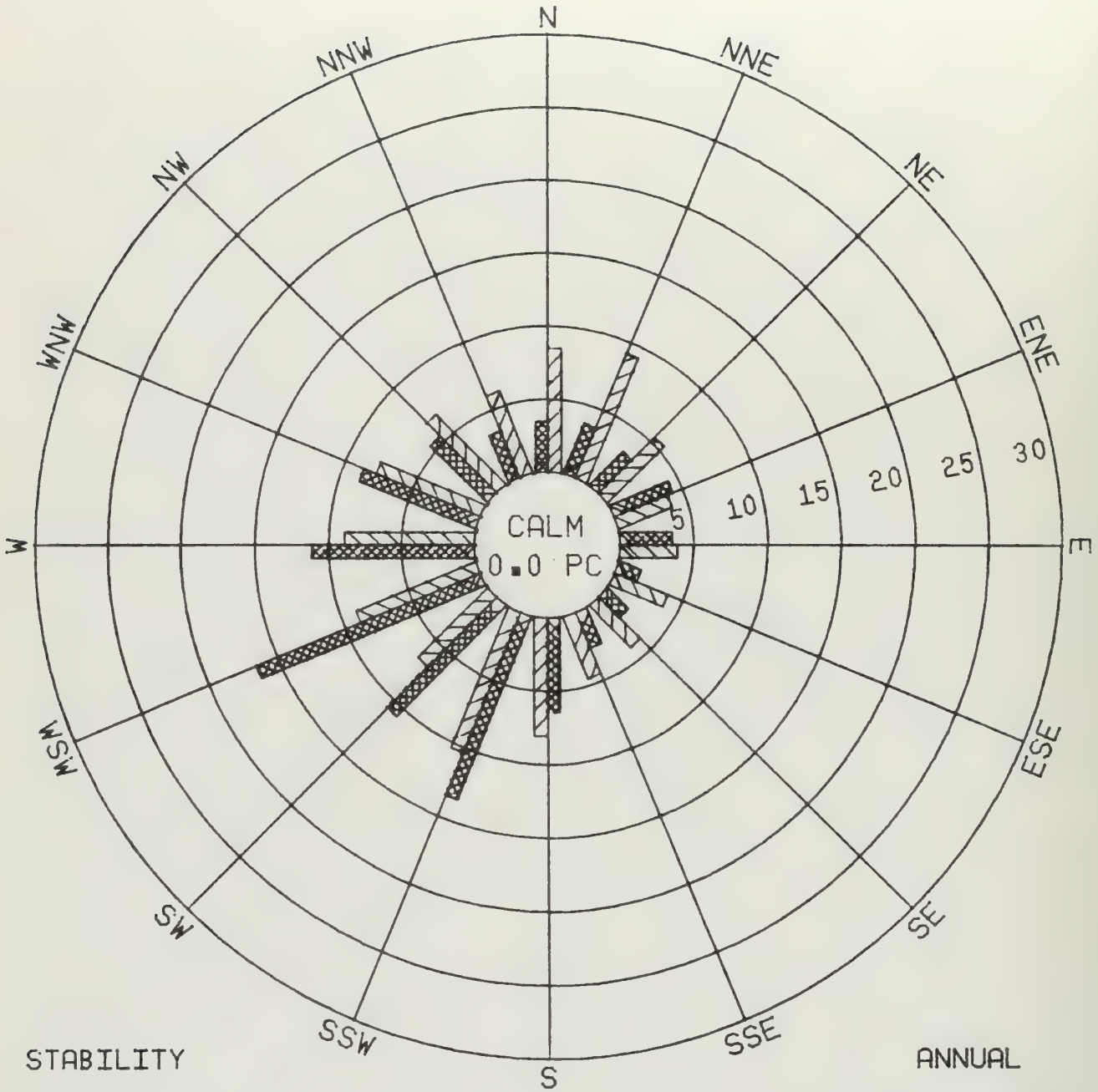


Figure 6-5-4

ANNUAL WIND ROSE, SITE 1 - 10 METERS

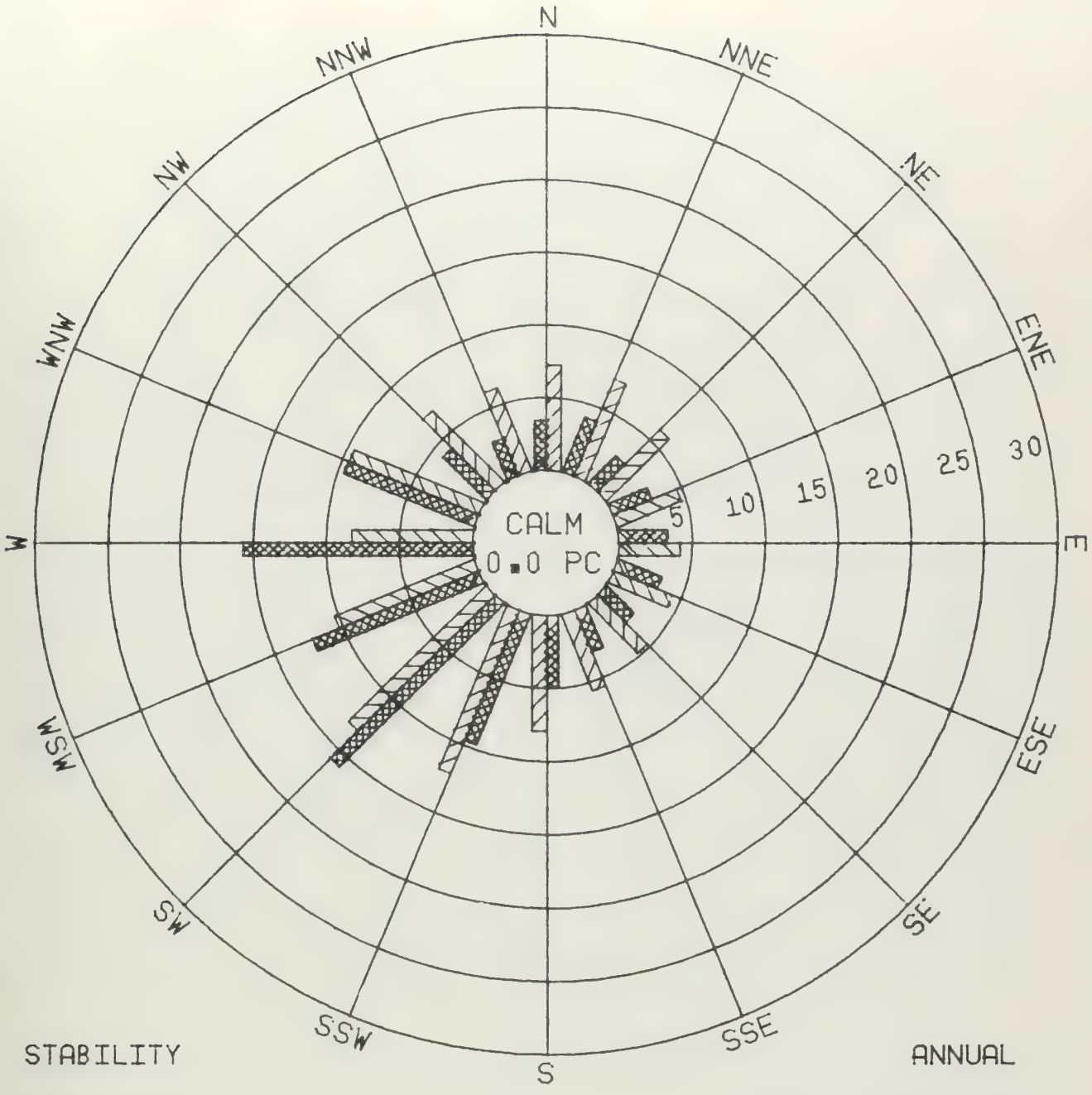


Figure 6-5-5

ANNUAL WIND ROSE, SITE 2 - 10 METERS

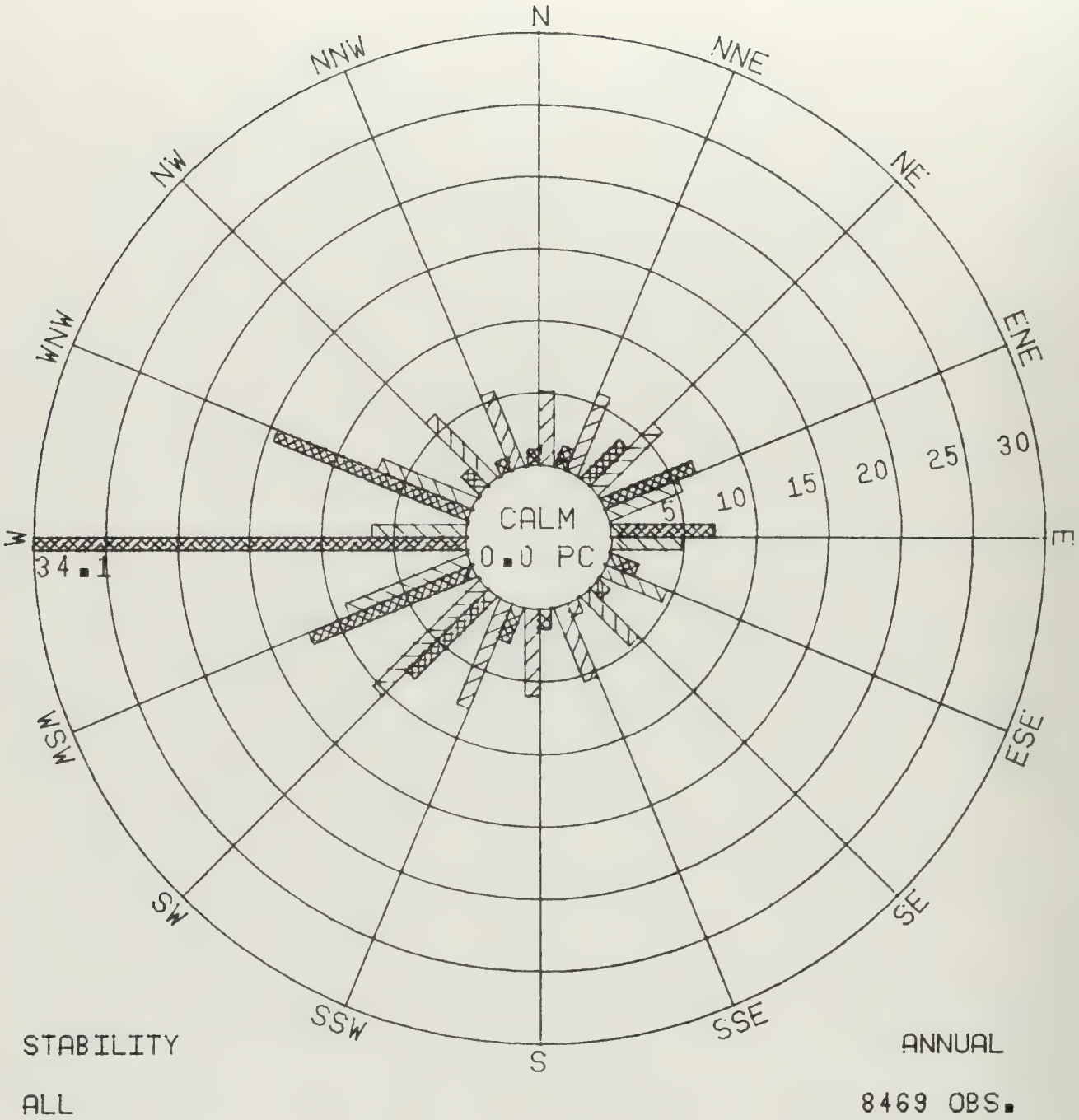
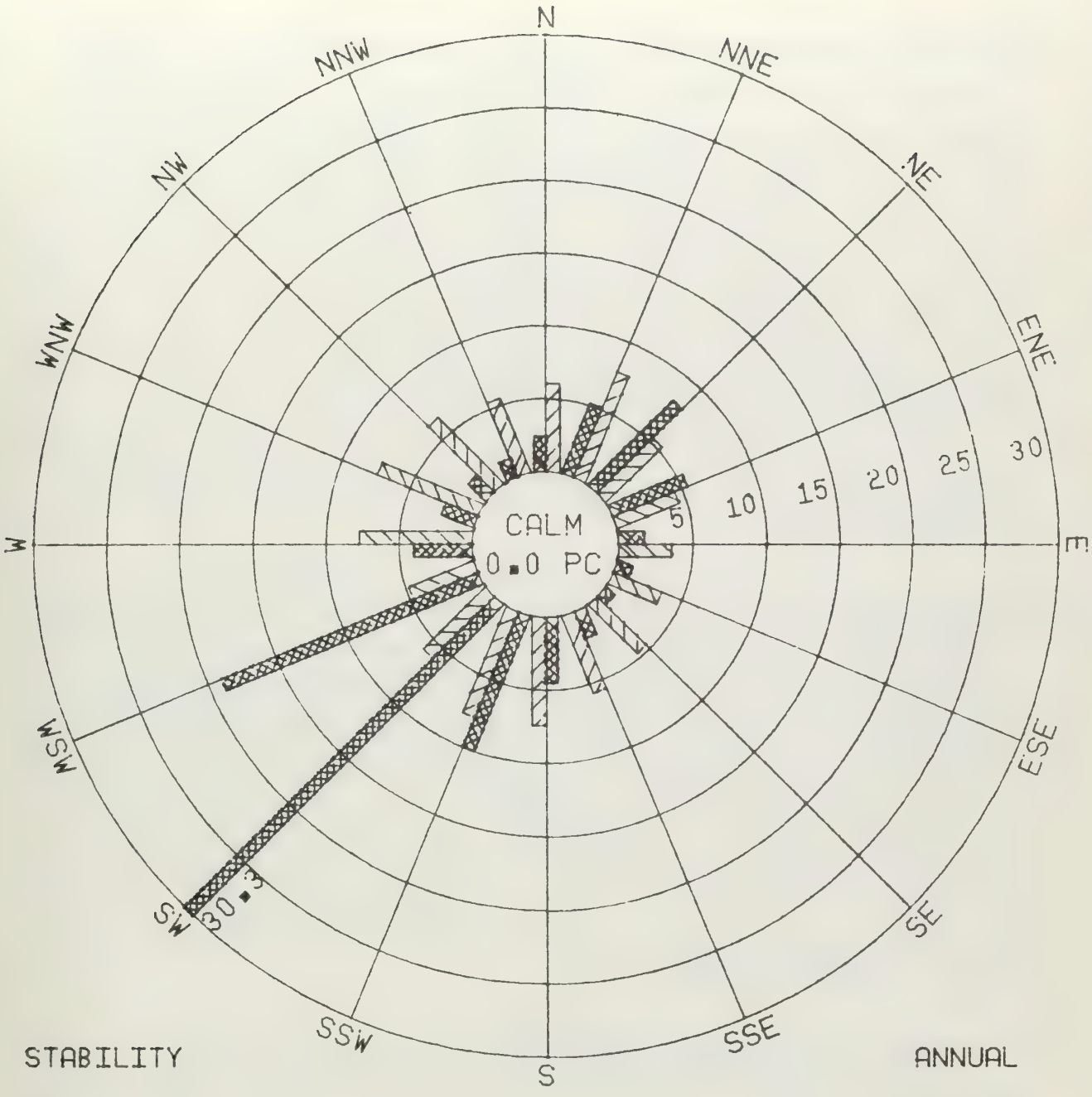


Figure 6-5-6

ANNUAL WIND ROSE, SITE 3 - 10 METERS



STABILITY

ALL

ANNUAL

8417 OBS.

WIND DIRECTION FREQUENCY (PERCENT)

MEAN WIND SPEED (MI/HR)

RIO BLANCO 9-1-75 TO 8-31-76

TOWER 4 10

Figure 6-5-7

ANNUAL WIND ROSE, SITE 4 - 10 METERS

the night. Predominant winds are from the western sectors as influenced by large-scale wind patterns. However, topographic influences frequently result in localized wind flows in the site region, especially during light wind conditions. During the day, winds are generally expected to flow up terrain slopes and/or up valley as the air is warmed by the surface of the slopes. During the evening, the reverse is true as cooler air drains down the slopes and gulches to lower elevations. Based on a review of the site data, there is a tendency for winds to flow from the western sectors during the night, as well as during moderate to high wind speed conditions, and from the eastern sectors during the day, especially from sunrise till noon and during light wind speed conditions. At times, strong winds from large scale pressure systems may dominate and minimize or nullify these local circulations.

Atmospheric stability is a relative indication of the dispersion potential of the atmosphere. Generally, stable conditions result in decreased dispersion compaired to neutral and unstable conditions. Assuming a ground level release, atmospheric dispersion will result in lower pollutant concentrations for unstable conditions than for neutral and stable conditions with the same wind speed. The converse is true for an elevated release for receptors close to the release but in the region prior to plume interaction with the ground surface. Atmospheric stability in this report is based on $\Delta T_{(60m-10m)}$ onsite data and classified according to the criteria presented in Table 6-5-10.

The annual distribution of atmospheric stability classes based on $\Delta T_{(60m-10m)}$ is summarized in Table 6-5-11. Joint frequency distributions of atmospheric stability and wind direction and speed data are summarized in Table 6-5-12. Neutral (D) and slightly stable (E) conditions predominate at Site 1, based on the available data. Review of the sequential data indicates the expected diurnal trend at the site (i.e., unstable and neutral conditions occur during the day while stable and neutral conditions occur at night). Although continuous ΔT measurements are not available for areas in the gulches (e.g., at Sites 3 and 4), review of the limited upper air profiles available for the site, which include vertical profiles within the

valleys, indicate that inversions are more intense at these lower terrain elevations. Therefore, the intensity and frequency of occurrence of inversions within the gulches are expected to be greater than based on Site 1 ΔT data, due to cold air drainage down the slopes at night.

Table 6-5-10

ΔT STABILITY CATEGORIES

	Range of Vertical Temperature Gradient ($^{\circ}C/100m$)	Turbulence Type
A = Very stable	$\Delta T < -1.9$	
B = Moderately Unstable	$-1.9 \leq \Delta T < -1.7$	High Atmospheric Turbulence
C = Slightly Unstable	$-1.7 \leq \Delta T < -1.5$	
D = Neutral	$-1.5 \leq \Delta T < -0.5$	Moderate Atmospheric Turbulence
E = Slightly Stable	$-0.5 \leq \Delta T < 1.5$	
F = Moderately Stable	$1.5 \leq \Delta T < 4.0$	Low Atmospheric Turbulence
G = Very Stable	$4.0 \leq \Delta T$	

Table 6-5-11

ANNUAL ΔT_{60-10m} STABILITY DISTRIBUTION

(Rio Blanco Site 1 Data, September 1, 1975 - August 31, 1976)

	Category						
	A	B	C	D	E	F	F
Frequency*,%	6.02	3.73	5.08	30.78	41.45	10.87	2.08

*Data set used includes T data that were simultaneously available for Site 1 - 30m wind data.

Table 6-5-12

JOINT FREQUENCY DISTRIBUTION OF ATMOSPHERIC STABILITY WIND DIRECTION AND WIND SPEED

Stability Class: A
Elevation: 30 Meters
Delta T (10 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	0	2	8	3	0	0	13
NNE	0	3	9	5	3	0	20
NE	0	1	11	7	1	0	20
ENE	0	1	2	1	0	0	4
E	0	2	1	0	0	0	3
ESE	0	0	1	0	0	0	1
SE	0	2	1	0	0	0	3
SSE	0	1	4	1	0	0	6
S	0	0	8	19	7	0	34
SSW	0	0	31	82	40	6	159
SW	0	1	27	37	4	1	70
WSW	0	1	40	10	2	1	54
W	0	2	29	12	6	4	53
WNW	0	0	10	18	2	1	31
NW	0	4	13	4	1	0	22
NNW	0	0	7	3	1	0	11
Variable	0	0	0	0	0	0	0
Totals	0	20	202	202	67	13	0

Periods of Calms 0 Hours

Stability Class B
Elevation: 30 Meters
Delta T (10 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	0	4	3	2	0	0	9
NNE	0	3	8	4	1	0	16
NE	0	1	7	1	0	0	9
ENE	0	2	5	0	0	0	7
E	0	2	1	0	0	0	3
ESE	0	2	0	0	0	0	2
SE	0	3	2	0	0	0	5
SSE	0	2	0	0	0	0	2
S	0	3	12	5	3	1	24
SSW	0	2	20	26	9	6	63
SW	0	3	9	15	2	0	29
WSW	0	2	21	7	0	0	30
W	0	3	29	14	7	1	54
WNW	0	1	11	8	5	0	25
NW	0	3	5	7	2	0	17
NNW	0	2	10	5	0	0	17
Variable	0	0	0	0	0	0	0
Totals	0	38	143	94	29	8	0

Periods of Calms 0 Hours

Stability Class: C
Elevation: 30 Meters
Delta T (10 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	0	3	4	1	0	0	8
NNE	0	5	6	8	1	0	20
NE	0	13	6	2	1	0	22
ENE	1	10	2	2	0	0	15
E	0	13	5	0	0	0	18
ESE	0	1	4	0	0	0	5
SE	0	3	0	0	0	0	3
SSE	0	4	4	0	0	0	8
S	0	6	15	4	4	3	32
SSW	0	6	22	30	12	9	79
SW	0	5	27	9	1	0	42
WSW	0	11	43	17	1	0	72
W	0	4	19	9	1	1	34
WNW	0	6	16	8	0	0	30
NW	0	6	11	5	0	1	23
NNW	0	4	9	1	0	0	14
Variable	0	0	0	0	0	0	0
Totals	1	100	193	96	21	14	0

Periods of Calms 0 Hours

Stability: D
Elevation: 30 Meters
Delta T (10 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	14	26	35	35	12	10	132
NNE	19	31	62	42	20	6	180
NE	33	54	31	11	1	0	130
ENE	48	138	9	0	0	0	195
E	37	99	8	0	0	0	144
ESE	10	42	4	1	0	0	57
SE	13	44	3	2	0	1	63
SSE	22	39	16	3	0	2	82
S	15	39	29	27	12	13	135
SSW	10	39	84	116	64	23	336
SW	10	66	113	107	10	3	309
WSW	9	78	106	76	27	4	300
W	8	27	45	66	38	13	197
WNW	14	22	26	39	33	14	148
NW	13	20	29	26	5	0	93
NNW	13	15	30	14	4	0	76
Variable	0	0	0	0	0	0	0
Totals	288	779	630	565	226	89	0

Periods of Calms 0 Hours

Table 6-5-12 Continued

Stability: E
Elevation: 30 Meters
Delta T (10 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	64	41	21	12	1	1	140
NNE	55	26	13	14	0	0	108
NE	60	26	9	2	0	0	97
ENE	81	35	2	2	0	0	120
E	55	28	5	1	0	1	90
ESE	31	21	1	0	0	1	54
SE	27	24	2	0	0	0	53
SSE	32	55	10	1	0	0	98
S	56	64	41	4	0	3	168
SSW	96	135	103	104	45	22	505
SW	72	234	202	51	10	3	572
WSW	51	143	198	112	16	4	524
W	60	61	71	56	16	9	273
WNW	95	56	40	27	10	6	234
NW	137	98	32	15	0	0	282
NNW	78	54	15	5	1	0	153
Variable	0	0	0	0	0	0	0
Totals	1050	1101	765	406	99	50	0

Periods of Calms 0 Hours

Stability F
Elevation: 30 Meters
Delta T (10 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	18	11	8	4	0	0	41
NNE	21	2	4	0	0	0	27
NE	23	5	3	1	0	1	33
ENE	23	5	2	2	0	0	32
E	9	3	1	2	0	0	15
ESE	6	5	1	0	0	0	12
SE	10	4	0	0	0	0	14
SSE	6	16	1	0	0	0	23
S	6	23	11	0	0	1	41
SSW	10	35	23	6	0	1	75
SW	15	33	93	2	0	0	143
WSW	14	15	90	66	2	1	188
W	8	9	28	25	0	0	70
WNW	12	9	25	28	0	1	75
NW	22	23	22	3	0	0	70
NNW	19	23	7	2	0	0	51
Variable	0	0	0	0	0	0	0
Totals	222	221	319	141	2	5	0

Periods of Calms 0 Hours

Stability Class: G
Elevation: 30 Meters
Delta T (10 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	1	0	2	1	0	0	4
NNE	2	0	5	2	1	0	10
NE	2	1	1	3	0	0	7
ENE	3	2	1	0	0	0	6
E	0	1	1	0	0	1	3
ESE	0	4	0	1	0	0	5
SE	0	0	0	0	0	0	0
SSE	1	0	0	0	0	0	1
S	1	2	3	3	0	0	9
SSW	1	2	4	6	1	1	15
SW	1	5	23	6	2	0	37
WSW	1	5	13	7	3	1	30
W	0	1	3	0	2	4	10
WNW	0	2	1	3	3	2	11
NW	2	1	9	0	0	0	12
NNW	2	0	11	1	0	0	14
Variable	0	0	0	0	0	0	0
Totals	17	26	77	33	12	9	174

Periods of Calms 0 Hours

Stability Class: All
Elevation: 30 Meters
Delta T (60 - 60) Meters

Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
			Miles Per Hour				
N	97	87	81	58	13	11	347
NNE	97	70	107	75	26	6	381
NE	118	101	68	27	3	1	318
ENE	156	193	23	7	0	0	379
E	101	148	22	3	0	2	276
ESE	47	75	11	2	0	1	136
SE	50	80	8	2	0	1	141
SSE	61	117	35	5	0	2	220
S	78	137	119	62	26	21	443
SSW	117	219	287	370	171	68	1232
SW	98	347	494	227	29	7	1202
WSW	75	255	511	295	51	11	1198
W	76	107	224	182	70	32	691
WNW	121	96	129	131	53	24	554
NW	174	155	121	60	8	1	519
NNW	112	98	89	31	6	0	336
Variable	0	0	0	0	0	0	0
Totals	1578	2285	2329	1537	456	188	174

Periods of Calms 0 Hours

Wind direction persistence data were not specifically summarized for the September 1, 1975-August 31, 1976 data period. However, summaries are available for the period February, 1975-January 1976 (RBOSP Final Environmental Baseline Report, 1977). The longest episodes of wind persistence during that period were: a 20-hr wind from the south-southwest at Site 1, a 47-hr wind from the northwest at Site 2, a 20-hr wind from the west-southwest at Site 3, and two occurrences of a 17-hr wind from the north at Site 4. At all four sites, the longer persistence episodes (10 hr or greater) occurred more frequently in the south-southwest through west-northwest sectors. However, there was also a secondary peak in the north and northeast sectors that was most pronounced at Site 4. A summary of inversion persistence episodes for the September 1, 1975-August 31, 1976 period is presented in Table 6-5-13 for Site 1.

Upper air data are required to supplement onsite tower measurements to support dispersion analyses for which plume rise is a significant factor.

Table 6-5-13

INVERSION* PERSISTENCE OCCURRENCES
(Rio Blanco Site 1-$\Delta T_{(60m - 10m)}$, September 1, 1975 - August 31, 1976)

Hrs.	Wind Direction															
DUR	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
1	37	51	77	57	41	60	71	125	205	259	248	237	224	158	99	67
2	5	3	7			1	4	18	31	48	79	38	44	20	5	8
3	1			0	0			0	8	15	35	13	17	7	1	0
4		0	0	0	0	0	0	3	5	2	14	7	5	2		0
5	0	0	0	0	0	0	0		2		7	2	1	0	0	0
6	0	0	0	0	0	0	0	0	0	0	2	1		1	0	0
7	0	0	0	0	0	0	0	0	0	0	2		0	1	0	0
8	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0

*Inversion is defined as $\Delta T \geq 0.0$

Onsite upper air data are available for only a limited time period for each season during 1 yr of the baseline period. Therefore, upper air data from Grand Junction collected by the National Weather Service were used to supplement the onsite tower data.

The approach used was to define a "critical level" at which onsite upper air data compare reasonably well with Grand Junction upper air data. Based on comparisons of the data sets for various selected days during the baseline period, a "critical level" of 10,000 ft MSL was chosen. Data between the 10,000 ft MSL level and the surface site data were obtained by linear interpolation in the case of temperature and wind direction and by use of the power law in the case of wind speed. (The complete vertical profile of relative humidity from Grand Junction was used to support the cooling tower study.) A limitation of the "critical level" approach is that occasionally details of the vertical profiles between the surface and 10,000 ft MSG are lost and frequently a nocturnal jet (i.e., in regions of relatively high wind speed) between 8,000 ft - 11,000 ft MSL was observed but was not accounted for in the profile generated for the dispersion analyses.

The mixing level is defined as the height above the surface below which relatively vigorous vertical mixing occurs. Therefore, the mixing level indicates the practical vertical limit of dispersion and is significant for dispersion over large distances and for cases involving significant plume rise. The upper boundaries of afternoon mixing levels were estimated by determining the intersector of the dry adiabatic extension of the maximum afternoon surface temperature with the vertical temperature profile observed at 1200 GMT (Holzworth, 1972).

Hourly mixing levels were determined using interpolation procedures used in the computer model CRSTER developed by EPA (Novak, 1976). Specifically, the computed afternoon mixing level was assumed to be applicable for the period between 1400 LST and sunset. A linear interpolation is used between sunset and the computed mixing level for the following day if the stability is not stable at sunrise. If stable conditions occur at sunrise, then

values are interpolated as before except that the mixing level is assumed to be zero at sunrise and a linear interpolation is used between sunrise and the computed afternoon mixing level. If this approach did not provide a finite result, the maximum available height of the Grand Junction sounding was used (generally 12,000-13,000 ft MSL for this analysis). It should be noted that, if local terrain height is taken into account, the annual afternoon mixing height is approximately 15,000 MSL for the site region, according to Holzworth.

2. Air Quality Standards and Classifications - The following discussion summarizes the ambient air quality regulations used for evaluating and interpreting the modeling results. Source references for this information can be found in Section 5.8 of this chapter.

a. Colorado State Standards - Colorado has adopted air pollution control regulations that promulgate both air quality standards and emission regulations equaling or exceeding the stringency of the National Ambient Air Quality Standards. For application of these regulations, the State of Colorado is divided into three Air Quality Category Regions. The Piceance Creek basin is currently classified as Category I. The ambient standards are presented in Table 6-5-14.

Table 6-5-14

STATE OF COLORADO AMBIENT AIR QUALITY STANDARDS

Emission	Averaging Time	Maximum Allowable Increments over Baseline ($\mu g/m^3$) Category I	Category II	Category III
SO_2	Annual	3	15	60
	24-hour max	15	100	260
	3-hour max	75	700	1300
		Maximum allowable ambient air concentrations		
Particulates	Annual		45	
	24-hour max		150	

b. Federal Standards - Two categories of Federal air quality regulations and standards are applicable to the oil shale development. These are presented below.

1) National Ambient Air Quality Standards (NAAQS) - National Ambient Air Quality Standards define the maximum allowable ground level Concentrations of pollutants over specified averaging periods. The applicable regulations are itemized in Table 6-5-15.

Table 6-5-15

NATIONAL AMBIENT AIR QUALITY STANDARDS

Emission	Averaging Time	Primary Standards (Human Health) ($\mu g/m^3$)	Secondary Standards (Public Welfare) ($\mu g/m^3$)
Sulfur Oxides (SO_2)	Annual	80	None
	24-hour*	365	None
	3-hour*	None	1,300
Nitrogen Dioxide (NO_2)	Annual	100	100
Particulates	Annual†	75	60
	24-hour*	260	150
Hydrocarbons (corrected for CH_4)	3-hour* (6-9 am)	160 ≠	160 ≠
Carbon Monoxide	8-hour*	10,000	10,000
	1-hour*	40,000	40,000
Oxidant (corrected for NO_2, SO_2)	1-hour*	160	160

* Not to be exceeded more than once per year.

† Geometric mean.

≠ A guideline, not a legally enforceable standard.

2) Significant Deterioration Regulations - Federal air quality "No Significant Deterioration" regulations limit the amount of pollutant which can be added to 1975 "baseline" concentrations. State of Colorado standards for sulfur dioxide (SO_2) are also written in terms of increments over baseline concentrations (see above). There are three area classifications involved in the Federal incremental standards. The Piceance Creek basin is subject to Class II regulations. Federal maximum allowable increments to air quality baselines are shown in Table 6-5-16. Class III standards state simply that pollutant levels are not to exceed the National Ambient Air Quality Standards.

Table 6-5-16
MAXIMUM ALLOWABLE FEDERAL INCREMENTS FOR AREA CLASSES;
NO SIGNIFICANT DETERIORATION REGULATIONS

Emission	Averaging Time	Class I ($\mu g/m^3$)	Class II ($\mu g/m^3$)
Particulates	Annual	5	10
	24-hour max	10	30
Sulfur Dioxide	Annual	2	15
	24-hour max	5	100
	3-hour max	25	700

*Geometric Mean

3. Source Emission Inventory - The plant configuration is discussed in Section 3 of this Detailed Development Plan. A discussion of emission

sources for in situ retorting, processing, and processed shale and overburden disposal for both Modular and Commercial Developmental Phases and controls for each were discussed previously in this section. A site plan of the location of the various processing sources is shown in Figure 6-5-1. Modeling was performed for two cases, the Modular Development Phase and Commercial Phase.

The technique of source grouping was applied to some emission sources used in the modeling analysis for annual averages. In a number of cases project operations have multiple stacks with identical operating parameters; stacks of this type were grouped together. The flow rate, temperature, stack diameter, and height of each composite stack were kept the same as each of the separate stacks making up the group. The source release rate from each group, however, was the sum of the emissions from the individual stacks in the group.

The source configurations and associated information used in the modeling analyses are presented in Tables 6-5-17 and 6-5-18. On these tables are the name given to each source or source group, the x, y, and z coordinates of the positions of each source (relative to the computer coordinate system), the stack heights of the respective sources in meters above the elevation of the base of the stack, and the release rate of each effluent in grams per second. The z coordinate is given in feet above mean sea level.

Also presented are the temperature of the effluent gas in degrees Kelvin, the diameter of the stack at the point of release in meters, and the effluent flow velocity out of the stack in meters per second.

Four major pollutants were modeled. These were SO_2, NO_2, particulates, and non-methane hydrocarbons (NMHC). Other substances for which National Ambient Air Quality Standards have been established will not be emitted by project operations in sufficient quantity to pose a potential pollution problem.

Table 6-5-17

MODULAR DEVELOPMENT PHASE
POLLUTANT EMISSION RATES AND STACK PARAMETERS

Stack	SO_2 Emission Rate (gms/sec)	Part. Emission Rate (gms/sec)	NMHC Emission Rate (gms/sec)	NO_x Emission Rate (gms/sec)	Height (m)	Diameter (m)	Exit Velocity (m/sec)	Temp. (Deg. K)	Volumetric Flow (m^3/sec)
1	46.7	5.3	0.3	104.7	100.6	4.6	18.3	505.0	304.13
2	9.4	4.1	0.6	7.8	100.6	2.3	14.9	644.1	61.91

Stack	x Coord (m)	y Coord (m)	z Coord (m)
1	10439.0	12840.0	2111.3
2	10516.0	12840.0	2111.3

Table 6-5-18

COMMERCIAL PHASE
POLLUTANT EMISSION RATES AND STACK PARAMETERS

Stack	SO_2 Emission Rate (gms/sec)	Part. Emission Rate (gms/sec)	NMHC Emission Rate (gms/sec)	NO_x Emission Rate (gms/sec)	Height (m)	Diameter (m)	Exit Velocity (m/sec)	Temp. (Deg. K)	Volumetric Flow (m^3/sec)
1	5.3	15.12	18.5	54.05	100.6	3.66	27.10	323.00	285.12
2	0.08	2.65	0.0	2.65	100.6	1.83	28.04	366.30	73.75
3	0.0	1.26	0.0	0.0	100.6	0.91	80.00	366.30	52.03
4	0.038	0.038	0.076	1.00	45.7	0.91	9.92	660.80	6.45
5	3.91	0.09	0.09	6.30	45.7	2.10	17.45	355.20	60.44
6	48.38	40.32	2.52	234.36	100.6	8.60	18.10	449.70	1051.39

Stack	x Coord (m)	y Coord (m)	z Coord (m)
1	8573.0	11392.0	2195.1
2	8687.0	11468.0	2195.1
3	8689.0	11354.0	2207.3
4	8496.0	11163.0	2219.5
5	8306.0	11125.0	2219.5
6	9335.0	11659.0	2182.9

4. Modeling Methodology - The method used for the modeling of air pollution dispersion is a set of well established mathematical techniques which takes into account physical considerations of the plant orientation and configurations with respect to surrounding terrain features.

The computer simulation analyses performed to assess the air quality impact of the proposed project were made using two different but related techniques. These were for long-term evaluations (annual periods) and short-term evaluations (3-hr and 24-hr periods). The long-term modeling and the initial short-term modeling (24-hr average) are based on the Gaussian plume equation. The model used was the EPA-developed CRSTER dispersion model (Novak, 1976), modified to account for terrain that exceeded the effective stack height and to treat terrain effects on plume behavior for different atmospheric stability regimes. The detailed short-term modelings (24-hr, 3-hr) are based on the segmented plume approach to the Gaussian plume equation. The model used was the AQPUF2 dispersion model (Chandler, 1977).

The following is a more detailed technical description of the modeling techniques used for an annual average and short-term (24 hour or less) predictions.

a. Long-Term Interval Modeling (CRSTER) - The pollutant is assumed to disperse in the horizontal and vertical directions according to the following equation:

$$X = \frac{Q}{2\pi\sigma_y\sigma_z\bar{u}} \exp\left\{-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)\right\}^2 \left[\exp\left\{-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right\} + \exp\left\{-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right\}\right]$$

The symbols used have the meanings given in Turner's "Workbook of Atmospheric Dispersion Estimates" (Turner, 1969). The values of σ_y and σ_z are determined from the ambient stability category and the distance downwind from the emission source using a modification of the Pasquill classification system (Novak, 1976). When a stability class 7 occurs the plume

does not reach the ground. The CRSTER program utilizes sequential surface and upper air meteorological data for a year. The upper air data consist of the morning and afternoon mixing heights for each day as determined by the method established by Holzworth (Holzworth, 1972). For this study, Grand Junction data were used to develop mixing heights. The surface meteorological data consist of 24 hourly values for each day of the year of the following parameters: stability class, wind speed and ambient temperature. The CRSTER model uses the above data to calculate hourly mixing heights (rural and urban), a flow vector and a randomized flow vector (flow vector plus n-4 degrees, where n is a random number between 0 and 9). The wind direction data are given in tens of degrees. For this study the ΔT data from the meteorology tower at Site 1 were used to specify the stability class for each hour. The winds were categorized by direction and speed from data measured at the 30 m and 10 m levels, respectively, at Site 1; and the ambient temperature was established from the 10 m sensor data at Site 1. During analysis of the tracer study data, it was observed that the 10 m wind directions tended to be influenced by the gulches. For an elevated release of a buoyant plume from Airplane Ridge, the use of data reflecting such an effect of local topography was not considered appropriate. Therefore, the 30 m wind direction data were used in the analysis.

Plume rise was calculated through the use of the Brigg's equation (Briggs, 1971) in this program. The approach developed by Briggs calculates plume rise as a function of stability class, wind speed, and downwind distance from the source as well as effluent release parameters and ambient temperature.

The equations accurately describe the behavior of plumes having temperatures greater than $50^{o}C$ above the abmient air temperature or volume release rates greater than $50m^{3}$/sec. All of the process stack effluents of both phases are in this buoyant plume category. The rise of buoyant plumes is determined primarily by stability because of the tendency of the air to augment or oppose their buoyancy. Near the source, the plume rise is in a transition region and is a function of distance downwind.

Further from the source, the plume effectively levels off. Because the formulation of plume rise depends upon the lapse rate for stable atmospheres, there are separate estimates of final plume rise for E and F stabilities. For unstable or neutral conditions there is only one estimate of the final plume rise.

In the CRSTER program multiple stacks are treated as if they are located at a single point. The predicted concentration arising from the effluent released from each stack is calculated at specified downwind distances. The sum total of the contributions from each stack at each downwind distance is obtained for each hour of a day and the result stored for use in calculating the 24-hr average for each day at each downwind distance.

The terrain in the vicinity of Tract C-a is relatively complex. To take into account the topographic variability in the modeling analysis, a modification of the technique developed by the EPA and used in the Valley Model, C9M3D, was incorporated into the CRSTER model. The CRSTER model as obtained from EPA was capable of accepting as input the terrain elevation for each specified downwind distance (five concentric rings about the source) for each 10 degree flow vector. The modifications to the program dealt with the modeling of plume interaction with the terrain.

Under stable conditions the calculated effective stack height (plume rise plus physical stack height) had the terrain elevation at each grid point subtracted from that of the stack base to result in a new effective stack height. However, the resultant effective stack height for the plume was never allowed to become less than 10 m in order to avoid impaction of the plume centerline on the terrain.

Under neutral or unstable conditions the plume was assumed to follow the terrain such that the effective stack height remained constant regardless of terrain variation.

The handling of these cases is illustrated in Figure 6-5-8.

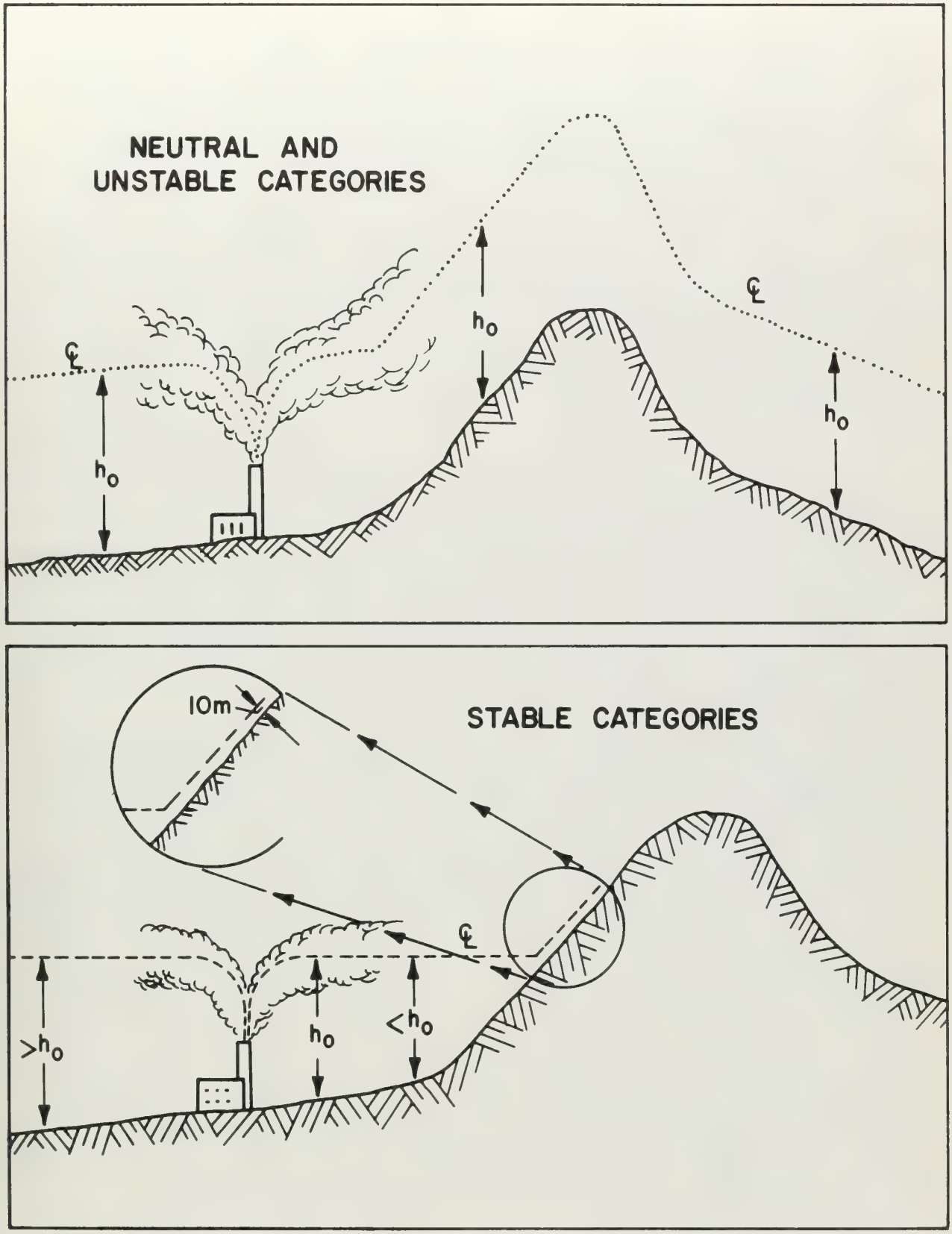


Figure 6-5-8

A SCHEMATIC DESCRIPTION OF THE PLUME HEIGHTS BEHAVIOR ASSUMED IN THE MODEL OVER "ROUGH" TERRAIN FOR UNSTABLE AND STABLE CONDITIONS, RBOSP

Unlike the Valley model, no correction to concentration is applied for the case of stable dispersion conditions. For this study, the CRSTER model was used for calculating pollutant concentrations out to 10 km. This distance included the major terrain variations that should influence elevated plumes released from Airplane Ridge.

b. Short-Term Interval Modeling - In order to estimate compliance with regulatory standards for short-term averaging intervals (i.e., 3-hr and 24-hr concentrations), a segmented plume model, AQPUF2, was used. The major differences between CRSTER and AQPUF2 for the short-term predictions are:

- the ability to treat multiple point and area sources that are spatially distributed.
- variable grid spacing for terrain is input.
- the ability to treat time and spatially varying wind fields.
- the ability to treat vertically varying meteorological parameters.
- the ability to use several advection steps for each meteorological observation period (i.e., each hour).

Thus, in the use of AQPUF2, all available meteorological data obtained from sites that are considered representative of air flow in which the plumes would be advected were used. Tracer studies were performed for RBOSP in October 1976. Analysis of the tracer study results showed that the two meteorological towers located in the gulches (Sites 3 and 4) actually were indicative only of conditions in the gulches. Since plumes did not generally descend into the gulches, only Sites 1 and 2 were used for this study.

Through interpolation procedures described below, AQPUF2 was used to calculate a vertically varying wind and temperature field for each puff at the end of each time step. Thus, although hourly meteorological data were used in this study, a spatially varying flow field was developed to advect the plume during each hour. The number of time steps (16 per hour) determined to adequately represent the plume advection was developed during analysis of the tracer study data.

The days to be examined in detail for the "worst case" analyses were selected from the CRSTER output. For each set of sources (Modular Development Phase, Commercial Phase), the days of the highest 24-hour average pollutant concentrations were identified. Additional information provided was the pollutant concentration, direction and distance to the highest concentrations. From this list, the five days of highest concentration were selected for analysis using AQPUF2. This procedure was followed for SO_2 and particulates. For hydrocarbons (HC), the CRSTER Program was modified to predict concentrations between 6 a.m. to 9 a.m. as required by the ambient air quality standards. The five days of highest 3-hour average HC concentrations for each phase were then selected for analysis using AQPUF2.

AQPUF2, as used for this study, incorporated the same plume rise and plume height-terrain-stability class considerations as were used in CRSTER. However, the atmospheric stability varied vertically as determined by the vertical temperature profile from the combined surface site data and Grand Junction upper air data. The modified Pasquill dispersion parameters (Gifford, 1961) applicable to each stability class were used in calculating the ground-level concentration resulting from each plume segment at specified grid points. These individual contributions for each time step were then summed to obtain an hourly average ground-level concentration at each grid point. The 24-hr average pollutant concentration at each grid point was obtained by summing the hourly average concentrations and calculating the mean for these 24 values.

In using the AQPUF2 program, the user specifies the number of time steps within the period of temporally constant meteorology data over which the plume is advected before the interpolated spatially varying meteorology is changed, the time interval at which the meteorological data set is varied, and the size and number of grid squares at which concentration calculations are to be performed. Thus, the detail required by the analysis can be set by the user. For this study, while the time interval between meteorological data points was specified by the manner in which the data were assembled, the time step at which the spatially varying meteorological data were stepped

was established from analysis of the tracer study data. Unlike CRSTER, the terrain elevation was input in a variable grid size format. This allowed the use of a closely spaced grid for areas where the terrain was highly variable while gradual elevation changes were accounted for by more widely spaced grid points.

5. Modeling Results - Analytical investigations were performed using two different grids, one for the CRSTER model calculations and one for the AQPUF2 model calculations. These grid sizes are rings from 0.75 km to 10 km for CRSTER and a 16 km x 18 km rectangle for the AQPUF2 model. The annual average pollutant concentrations were obtained using the CRSTER program. The short-term pollutant concentrations result from the worst case analyses using the AQPUF2 program. Concentrations are presented as micrograms per cubic meter ($\mu g/m^3$).

The short-term pollutant concentrations predicted by AQPUF2 will differ from those predicted by CRSTER as regards both the predicted peak concentrations and their location. Generally, AQPUF2 predictions were less than CRSTER predictions for the same meteorological data base.

The differences between the CRSTER and the AQPUF2 results can be explained by the method of modeling:

- details of terrain representation.
- locations
- spatial and temporal variation of the meteorological field; and
- sequential emissions (puff segments) from all sources.

In CRSTER, terrain is represented by a polar grid formed by the intersection of 36 radial lines (10 degree increments in direction from north) and five concentric circles centered on the source at user-specified downwind distances. AQPUF2 has a variable grid with about 800 points to represent the terrain for this study. The differences in the treatment of terrain are likely to cause differences in the pollutant concentration calculated by the two models.

In CRSTER stacks must be colocated while in AQPUF2 sources can be located with independent horizontal corrdinates. Since colocation of the sources results in superposition of plume centerlines, the AQPUF2 predictions of ground level concentration near the sources are very likely to be lower than those obtained from CRSTER under identical meteorological conditions.

In CRSTER, data from a single surface meteorological station are used with the parameters specified as constant over each hour. Similarly, upper air data in the form of mixing heights are also specified as constant for each hour. Data from multiple surface meteorological stations and vertical profiles of wind speed and direction and temperatures can be used in AQPUF2. These parameters can be calculated for each plume segment at a user-specified time interval so the spatial variations in the meteorological fields can be accounted for within the interval of the meteorological observations. Thus, for AQPUF2, the wind speed, wind direction, ambient temperature, and stability class will generally be different for any plume segment than those used in CRSTER. These differences will result in different predictions of pollutant concentrations.

Finally, CRSTER is a straight-line model. That is, the plume centerline is assumed to be colinear with the wind direction and is instantaneously advected over all downwind locations. Emissions occurring during one hour are not considered in the next. In AQPUF2, the plume centerline is curvilinear, advection distance for each plume segment is determined by the wind speed and the specified time interval, and plume segments due to emissions from the previous two hours are tracked in addition to those emitted during the current hour. Thus, CRSTER will always record a concentration at a downwind receptor within the interval of meteorological observation. AQPUF2, on the other hand, only records a concentration if a puff segment can reach the vicinity of the receptor, since the model accounts for plume meander in a spatially and temporally varying meteorological field. This difference in the treatment of plume advection is probably the most significant cause of the different predictions in pollutant concentrations observed in this study. Detailed analysis of the tracer study data indicates that a straight line model is inappropriate

for calculating short-term concentrations around Tract C-a.

The impacts of the Modular Development Phase are presented first followed by those of the Commercial Development Phase. For all long-term (annual) average plots, the 30 m level wind direction, 10 m level wind speed and ambient temperature and ΔT from Site 1 were used as input to the model. The figures depicting the short-term results include the baseline day which resulted in the calculated maxima. The upper air data from Grand Junction were merged with meteorological data from Site 1 for the same time period, and the mixing heights for the year or data were calculated. The onsite upper air data were used to ensure compatibility of the results using this hybridized data set (i.e., to ensure the resultant mixing depths could be considered representative of the site). For the short-term pollutant averages, the details of the resultant vertical profiles were used in AQPUF2.

The modeling results for elevated stack releases are presented first. The calculated effects do not include ground level and fugitive particulates emissions or CO and NO_x emissions from the mine ventilation system. Different techniques are used to simulate these sources; these are described in this chapter after the elevated releases are discussed.

a. Modular Development Phase - The results of the modeling analysis indicate that the Modular Development Phase operations will meet present applicable ambient air and "no significant deterioration" standards set by both EPA and the State of Colorado except for the present Colorado Category I annual average SO_2 standard. All Colorado Category II standards for SO_2 will be met during these operations. A summary comparison of modeling results for the Modular Development Phase operation with standards is given in Table 6-5-19. A more detailed discussion of the modeling of individual pollutants follows.

Table 6-5-19

COMPARISON OF MODELING RESULTS WITH APPLICABLE STANDARDS FOR MODULAR DEVELOPMENT PHASE OPERATION

Applicable Standard	Emission	Averaging Time	Standard Limit (ug/m^3)	Maximum Predicted Off-Site Increment Due to Development (ug/m^3)	Predicted Off-Site Value (ug/m^3)
State - Category I					
Max. allowable increment	SO_2	Annual	3	3.2	NA
		24-hour	15	5	NA
		3-hour	75	30	NA
Federal - Class II					
Max. allowable increment	SO_2	Annual	15	3.2	NA
		24-hour	100	5	NA
		3-hour	700	30	NA
	Particulates	Annual*	10*	0.3	NA
		24-hour	30	1.0	NA
Colorado Ambient Air Quality Standard	Particulates	Annual	45	0.3	9
		24-hour	150	1.0	10
National Ambient Air Quality Standards					
Primary	SO_2	Annual	80	3.2	8.4
		24-hour	365	5	10.2
Secondary	SO_2	3-hour	1300	30	35.2
Primary	NO_2	Annual	100	6	8
Primary	Particulates	Annual	75	0.3**	9
		24-hour	260*	1.0	10
Secondary	Particulates	Annual	60	0.3**	9
		24-hour	150	1.0	10
Primary	NMHC	3-hour (6-9 AM)	160	0.3	65

* Geometric Mean

** Arithmetic Average

NA - Not Applicable

1) Sulfur Dioxide - Figure 6-5-9 presents the isopleths of the ground level concentration increments of SO_2 over an annual period. The applicable State of Colorado standards (Table 6-5-14) for the present categorization of the Piceance Creek basin (Category I) is 3 $\mu g/m^3$. The maximum predicted increment of 3.2 $\mu g/m^3$ exceeds this regulation. The Federal allowable increment (Table 6-5-16) is 15$\mu g/m^3$ on an annual average basis. The fact that the point of highest concentration occurs on the prevailing windward side of the tract should be noted. Southwesterly winds occur most often; however, the downwind concentrations produced under these conditions are quite low. Winds from the easterly quadrant, which have a low frequency of occurrence, produce the highest concentration under stable atmospheric dispersion with advection toward the Cathedral Bluffs to the west of the tract.

Figures 6-5-10 and 6-5-11 present the 24-hr highest and second highest ground level concentration increments of SO_2 for the Modular Development Phase operation during the year examined. These values would be expected for the stable conditions in conjunction with light winds observed on these days. Again the concentrations to the east are low relative to those to the west. The predicted point of maximum 24-hr concentration increment of SO_2 during these operations is on the higher elevations immediately to the west and southwest of the tract. This point is outside the tract boundary. The applicable State of Colorado standard is 15 $\mu g/m^3$. The Federal allowable increment is 100 $\mu g/m^3$ for the 24-hr maximum value (Tables 6-5-14 and 6-5-16).

Figures 6-5-12 and 6-5-13 present the 3-hr highest and second highest ground level concentrations of SO_2 during the year from Modular Development Phase operations. The highest off-site concentrations again occur to the west of the complex with a 3-hr maximum concentration of 30 $\mu g/m^3$. The appropriate Category I State of Colorado incremental standard is 75 $\mu g/m^3$ (Category II is 700 $\mu g/m^3$) and the Federal 3-hr maximum incremental standard for SO_2 is 700 $\mu g/m^3$ (Tables 6-5-14 and 6-5-16)

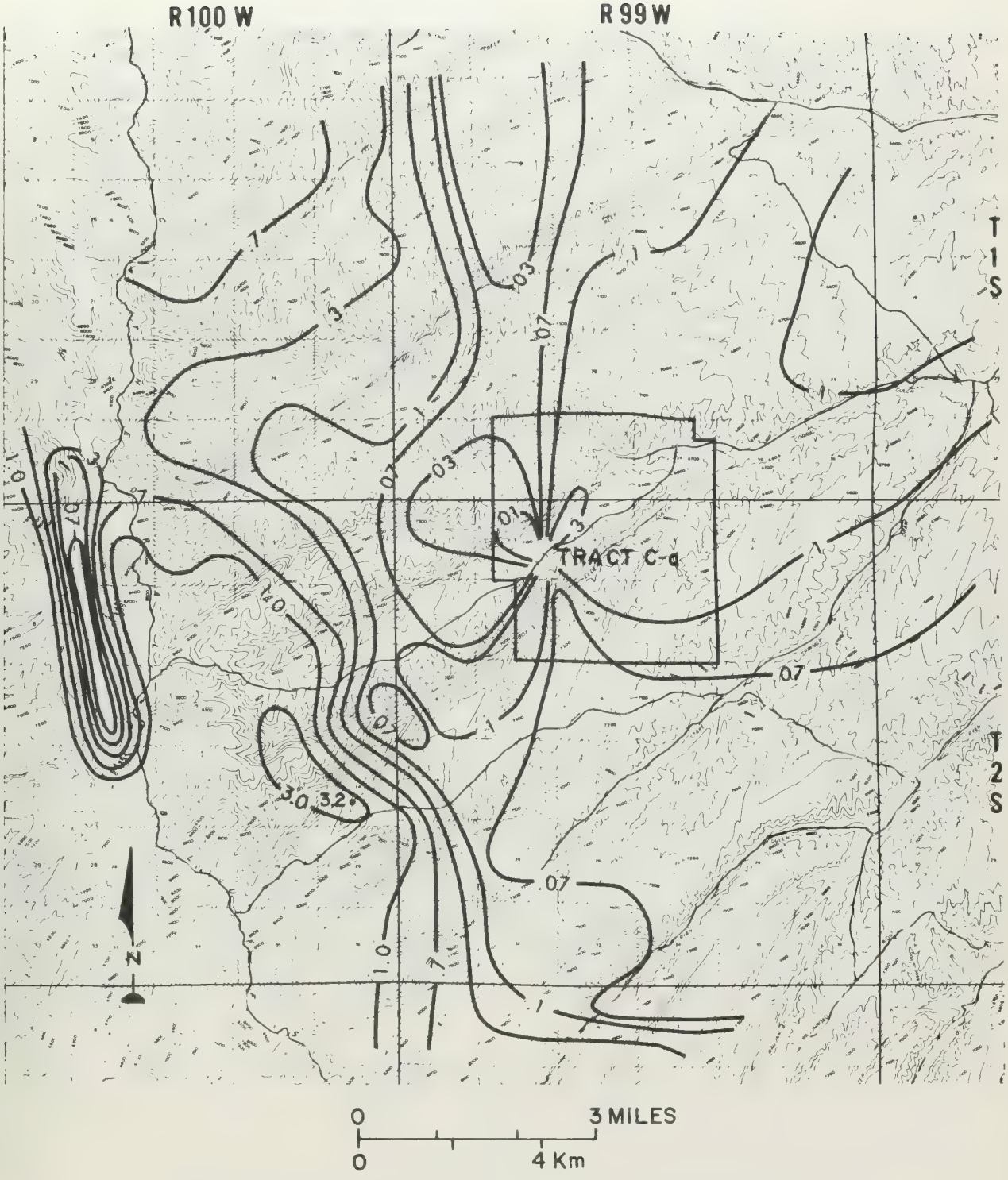


Figure 6-5-9
PREDICTED ANNUAL MEAN CONCENTRATIONS OF SO_2 ($\mu g/m^3$)
MODULAR DEVELOPMENT PHASE

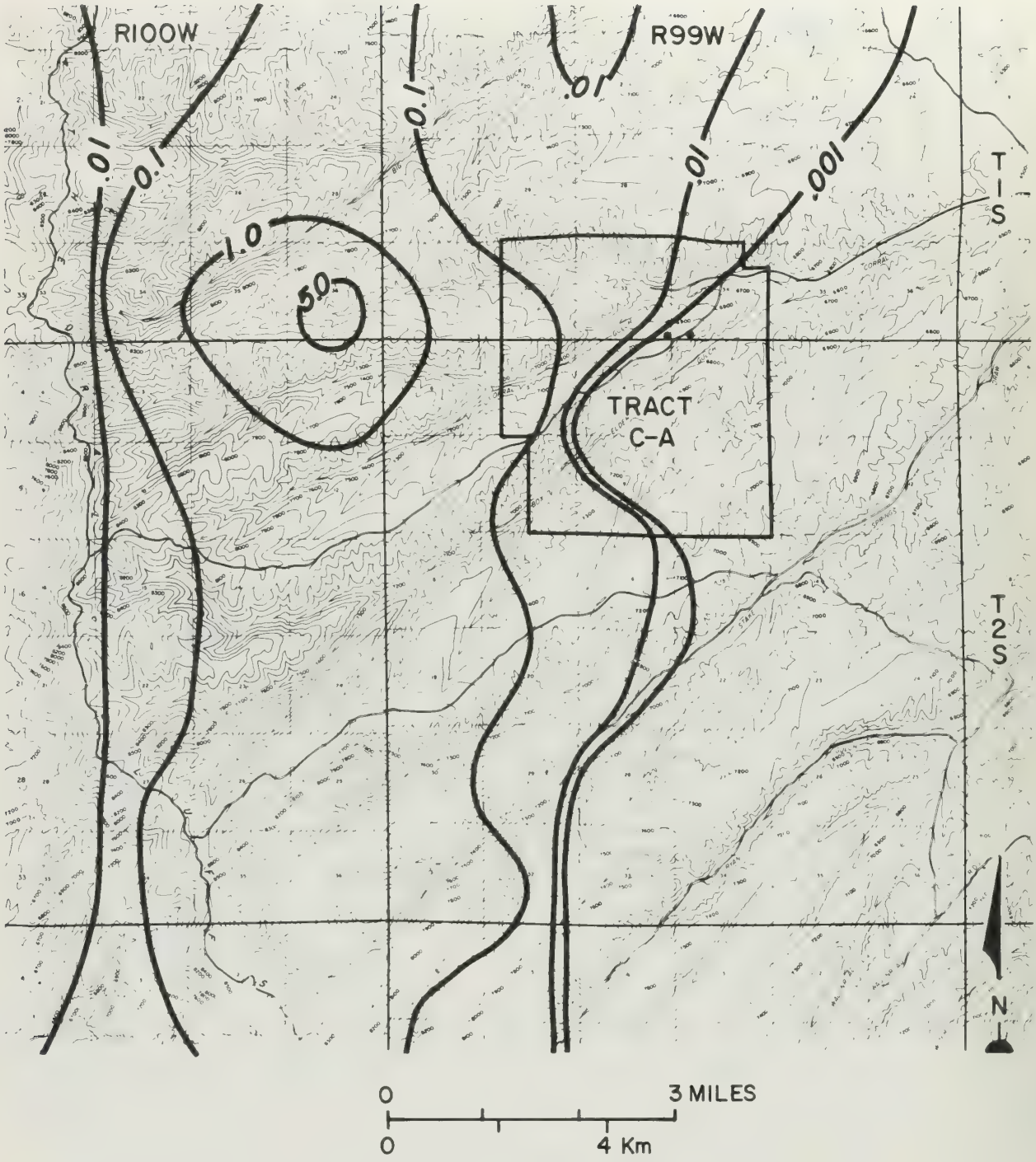


Figure 6-5-10
HIGHEST PREDICTED SO_2 CONCENTRATIONS ($\mu g/m^3$),
24-HOUR AVERAGE, MODULAR DEVELOPMENT PHASE
JAN. 22, 1976

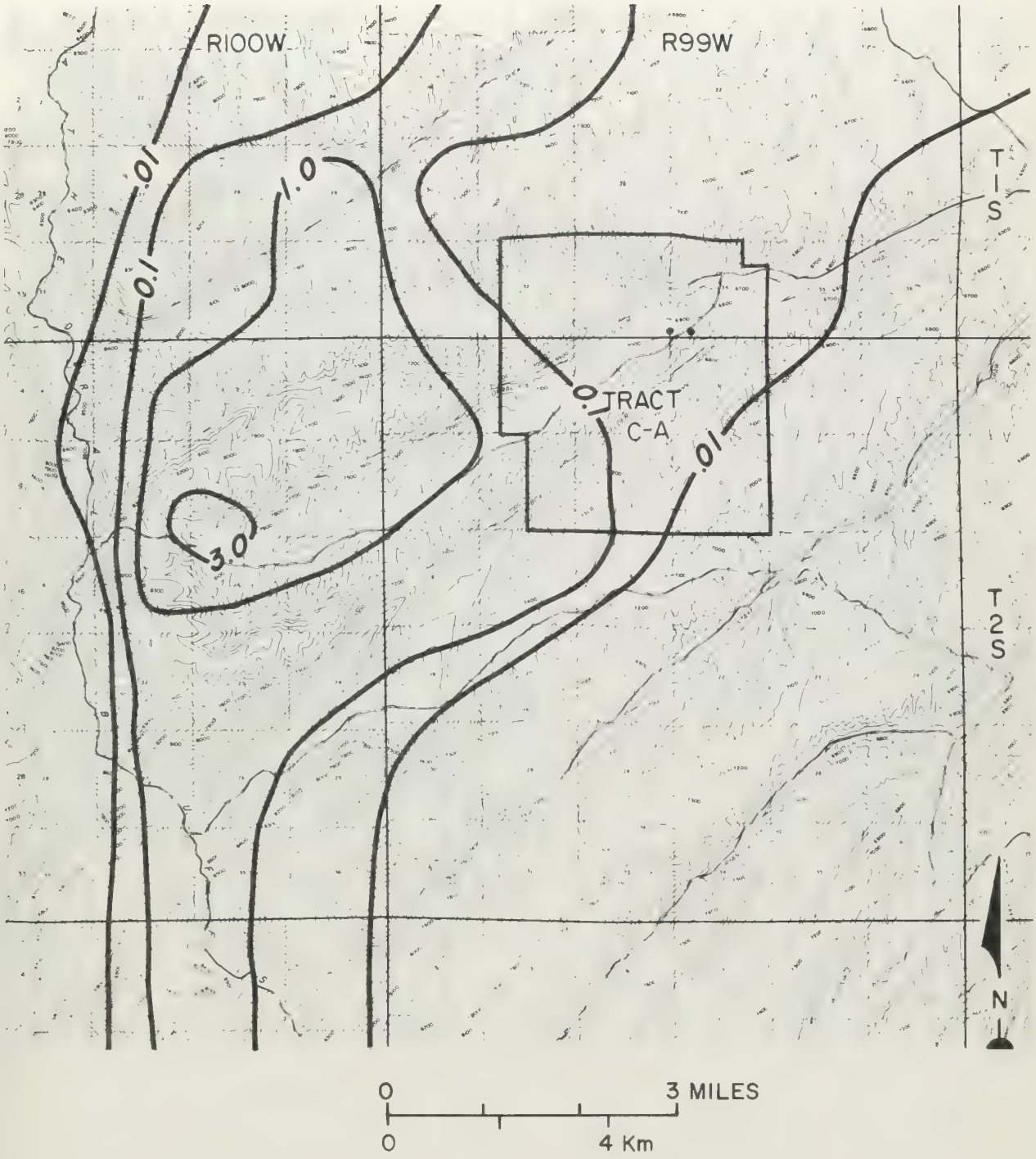


Figure 6-5-11
SECOND HIGHEST PREDICATED SO_2 CONCENTRATION ($\mu g/m^3$),
24-HOUR AVERAGE, MODULAR DEVELOPMENT PHASE
NOV. 4, 1975

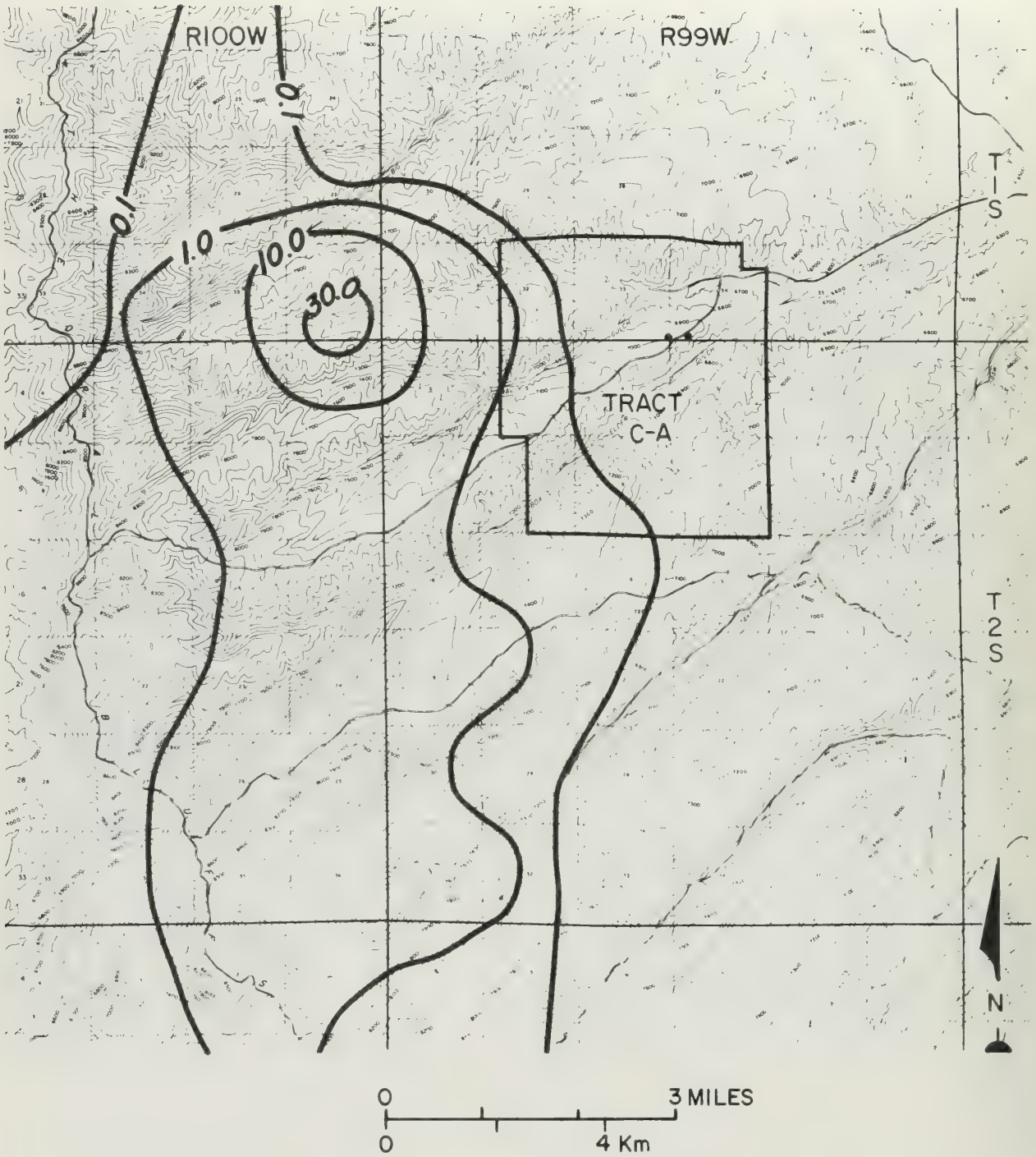


Figure 6-5-12
HIGHEST PREDICTED SO_2 CONCENTRATIONS ($\mu g/m^3$),
3-HOUR AVERAGE, MODULAR DEVELOPMENT PHASE
JAN. 1, 1976

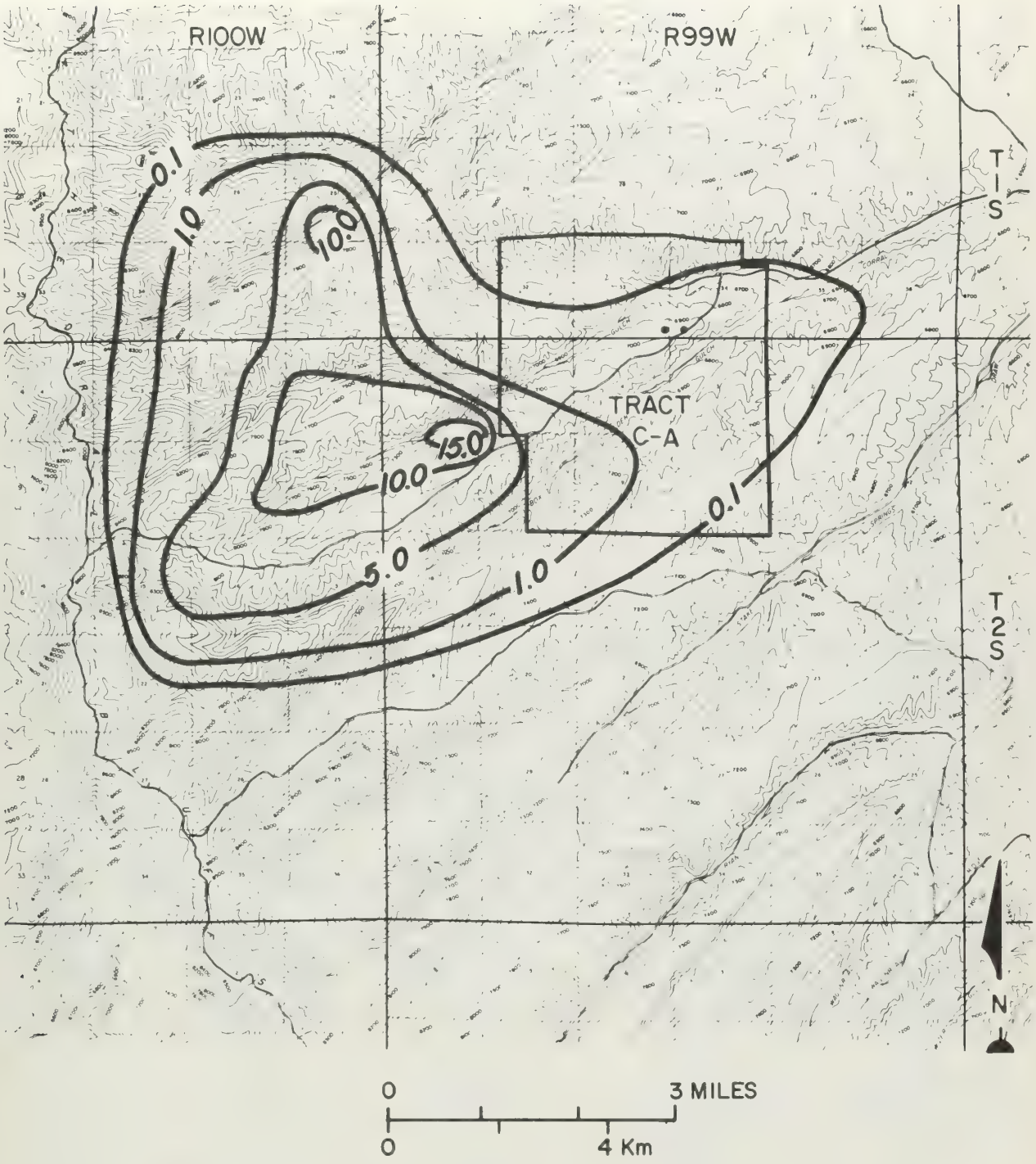


Figure 6-5-13
SECOND HIGHEST PREDICTED SO_2 CONCENTRATIONS ($\mu g/m^3$),
3-HOUR AVERAGE, MODULAR DEVELOPMENT PHASE
NOV. 4, 1975

Table 6-5-20 lists the maximum 24-hour average SO_2 concentration and the day of occurrence predicted by CRSTER for the Modular Development Phase. Table 6-5-21 lists the terrain elevations above sea level for each ring distance and direction. The meteorological data used were the Site 1 tower data and the Grand Junction upper air data for the year (September 1975-August 1976) selected for analysis.

2) Nitrogen Dioxide - The annual average expected ground level concentrations of NO_2 from the Modular Development Phase operations are shown in Figure 6-5-14. The maximum predicted concentration of approximately 6 $\mu g/m^3$ is due west of the plant site. This maximum concentration is within the National Ambient Air Quality Standards of 100 $\mu g/m^3$ for NO_x (Table 6-5-15).

3) Particulates - Figure 6-5-15 shows the expected ground level concentration increments of particulates during the Modular Development Phase operations. This figure does not reflect the impact of fugitive dust emissions and dust emissions from materials handling operations. These dust emissions are discussed in Section 5.7.A.5.c. The Federal incremental standard is 10 $\mu g/m^3$ over an annual period (Table 6-5-16). The Federal standard is expressed as a geometric mean, while the predicted increments shown on the plots are arithmetic means. A geometric mean, however, is always less than an arithmetic mean. Therefore, it is apparent that the particulate increments will be within presently applicable standards.

The expected 24-hr highest and second highest increments in ground level particulate concentration from these operations for the year of data examined are presented in Figures 6-5-16 and 6-5-17. As with the similar increments to the short-term maximums for SO_2 and non-methane hydrocarbons, the 24-hr maximum increments for particulates were calculated under light winds and stable conditions. The maximum increments of particulates offsite are about 1 $\mu g/m^3$, compared to the Federal Class II non-deterioration regulation of 30 $\mu g/m^3$ for a 24-hr maximum (Table 6-5-16).

Table 6-5-20

MAXIMUM 24 HOUR AVERAGE SO_2 CONCENTRATIONS
CRSTER MODEL - MODULAR DEVELOPMENT PHASE

RANGE DIR	0.8 KM	1.5 KM	2.3 KM	3.0 KM	4.5 KM
1	4.052AE-06 (193)	2.50A1E-06 (192)	2.1027E-06 (227)	1.7A11E-06 (351)	1.3254E-06 (208)
2	1.0050E-05 (23A)	4.527AE-06 (295)	3.4072E-06 (295)	3.0822E-06 (295)	2.291AE-06 (295)
3	1.4501E-05 (23A)	4.0049E-06 (295)	3.5230E-06 (271)	2.7046E-06 (271)	1.6639E-06 (271)
4	1.1173E-05 (23A)	2.675AE-06 (344)	2.459AE-06 (344)	1.9722E-06 (344)	1.6544E-06 (165)
5	9.0992E-06 (192)	3.736AE-06 (192)	1.A94AE-06 (192)	1.5091E-06 (6A)	1.0A72E-06 (304)
6	1.0220E-05 (192)	4.196AE-06 (192)	2.1170E-06 (192)	1.6043E-06 (192)	1.2127E-06 (299)
7	1.476AE-05 (329)	4.A32AE-06 (329)	3.0025E-06 (286)	2.6A31E-06 (286)	2.0A74E-06 (191)
8	1.924AE-05 (329)	5.A37AE-06 (329)	3.A810E-06 (331)	2.9120E-06 (331)	2.13C0E-06 (331)
9	1.32A7E-05 (329)	3.5237E-06 (329)	2.7062E-06 (29A)	2.6A0AE-06 (293)	2.1793E-06 (293)
10	4.6A4AE-06 (329)	2.452AE-06 (16)	2.4761E-06 (16)	2.2381E-06 (16)	1.5091E-06 (16)
11	4.7120E-06 (2)	2.302AE-06 (322)	2.3345E-06 (26A)	1.9A63E-06 (26A)	1.2942E-06 (26A)
12	4.A94AE-06 (2)	1.9247E-06 (322)	1.9772E-06 (26A)	1.752AE-06 (26A)	1.2A13E-06 (26A)
13	4.0A94E-06 (325)	1.4912E-06 (325)	1.3365E-06 (28A)	1.3522E-06 (332)	1.1142E-06 (332)
14	1.0A20E-05 (325)	3.7335E-06 (325)	1.7679E-06 (325)	1.4933E-06 (242)	1.2A03E-06 (242)
15	1.50A9E-05 (325)	5.5437E-06 (325)	2.5623E-06 (325)	2.0A3AE-06 (197)	1.7A01E-06 (197)
16	1.1A59E-05 (325)	4.7225E-06 (255)	4.4214E-06 (255)	3.3431E-06 (255)	2.0322E-06 (255)
17	4.471AE-06 (325)	3.0063E-06 (255)	2.757AE-06 (255)	2.1752E-06 (255)	1.3545E-06 (255)
18	8.76A1E-06 (326)	3.0749E-06 (326)	2.0753E-06 (256)	1.6A90E-06 (256)	1.0A34E-06 (256)
19	2.1721E-05 (326)	8.A022E-06 (326)	4.6575E-06 (326)	3.5182E-06 (326)	2.3674E-06 (326)
20	2.A20AE-05 (326)	1.2524E-05 (326)	6.A94AE-06 (326)	5.1AA6E-06 (326)	3.A325E-06 (326)
21	2.1386E-05 (326)	8.5931E-06 (326)	4.3635E-06 (326)	4.A04AE-06 (259)	2.1904E-06 (326)
22	1.0A63E-05 (194)	3.2037E-06 (258)	3.1452E-06 (30)	3.131AE-06 (30)	2.3096E-06 (30)
23	7.37A3E-06 (194)	2.3501E-06 (194)	1.4249E-06 (25A)	1.006AE-06 (16)	1.3496E-06 (32)
24	4.5155E-06 (216)	6.0703E-06 (216)	2.9019E-06 (216)	2.7247E-06 (216)	1.6A8AE-06 (216)
25	6.0422E-06 (216)	8.6009E-06 (216)	4.3712E-06 (216)	3.6A23E-06 (216)	8.0960E-06 (189)
26	4.9530E-06 (294)	5.776AE-06 (216)	2.760AE-06 (216)	6.375AE-06 (366)	1.5929E-05 (366)
27	6.5209E-06 (296)	2.7522E-06 (296)	1.9275E-06 (296)	1.701AE-06 (296)	9.4622E-06 (111)
28	4.5577E-06 (296)	1.6635E-06 (296)	1.0A09E-06 (296)	9.4853E-07 (363)	6.60A3E-06 (76)
29	1.7041E-06 (296)	4.7925E-07 (192)	4.7621E-07 (5)	4.8302E-07 (12)	1.4553E-06 (149)
30	1.5332E-06 (192)	4.2281E-07 (192)	3.3269E-07 (9)	2.0781E-06 (366)	5.5761E-06 (366)
31	9.6937E-07 (19)	6.4111E-07 (19)	5.4734E-07 (9)	6.840AE-07 (366)	1.9986E-06 (209)
32	7.4A31E-07 (19)	1.0534E-06 (192)	8.80A5E-07 (192)	6.7289E-07 (192)	1.7942E-06 (140)
33	4.0249E-07 (328)	1.184AE-06 (192)	1.028AE-06 (192)	4.3570E-06 (366)	7.760AE-06 (366)
34	1.0052E-06 (328)	7.4120E-07 (192)	8.4422E-07 (225)	8.409AE-07 (225)	9.1952E-07 (9)
35	1.7109E-06 (224)	1.2203E-06 (217)	1.0891E-06 (313)	1.196AE-06 (313)	9.9054E-07 (313)
36	3.3770E-06 (224)	1.9711E-06 (192)	1.2453E-06 (284)	1.1187E-06 (284)	8.2000E-07 (284)

6.0 KM	7.0 KM	8.0 KM	9.0 KM	10.0 KM
9.8243E-07 (208)	8.6A30E-07 (37)	8.5042E-07 (37)	8.3A20E-07 (89)	8.0054E-07 (89)
1.7045E-06 (295)	1.5507E-06 (157)	1.5926E-06 (157)	1.5A83E-06 (157)	1.5550E-06 (157)
1.3740E-06 (77)	1.4277E-06 (162)	1.4973E-06 (162)	1.5227E-06 (162)	1.5177E-06 (162)
1.4203E-06 (165)	1.2704E-06 (165)	1.2015E-06 (104)	1.2381E-06 (104)	1.2597E-06 (104)
8.6A0AE-07 (270)	8.0592E-07 (127)	8.9811E-07 (127)	9.620AE-07 (127)	1.0023E-06 (127)
9.764AE-07 (316)	8.7167E-07 (316)	7.8244E-07 (316)	7.4960E-07 (103)	8.0052E-07 (103)
1.724AE-06 (191)	1.5503E-06 (191)	1.4571E-06 (38)	1.4821E-06 (38)	1.48A0E-06 (38)
1.6715E-06 (331)	1.4701E-06 (331)	1.3189E-06 (331)	1.3263E-06 (137)	1.3172E-06 (137)
1.6581E-06 (293)	1.5A80E-06 (293)	1.1771E-06 (293)	1.0144E-06 (293)	8.8954E-07 (293)
1.1539E-06 (16)	1.0404E-06 (90)	1.0304E-06 (90)	1.000AE-06 (90)	9.6040E-07 (90)
9.2177E-07 (268)	7.7405E-07 (268)	7.1434E-07 (201)	6.6941E-07 (201)	6.6306E-07 (202)
9.4513E-07 (268)	8.2054E-07 (268)	7.260AE-07 (268)	6.5366E-07 (268)	5.9861E-07 (268)
8.46A9E-07 (332)	7.1244E-07 (332)	6.1086E-07 (332)	5.3487E-07 (332)	4.7760E-07 (332)
8.8793E-07 (242)	7.3397E-07 (242)	6.1428E-07 (242)	5.2180E-07 (242)	4.5085E-07 (242)
1.2925E-06 (197)	1.0A8AE-06 (197)	9.2851E-07 (197)	8.0659E-07 (197)	7.1556E-07 (197)
1.4390E-06 (212)	1.2216E-06 (212)	1.0358E-06 (212)	4.2058E-06 (53)	7.6522E-06 (20)
9.2A94E-07 (255)	1.1665E-06 (256)	1.1846E-06 (256)	6.5198E-06 (359)	1.2206E-05 (359)
7.7914E-07 (194)	1.1299E-06 (61)	1.2628E-06 (61)	4.8034E-06 (61)	6.9321E-06 (22)
1.7A29E-06 (326)	1.7028E-06 (173)	1.7581E-06 (173)	4.1317E-06 (20)	6.1892E-06 (318)
2.8240E-06 (326)	2.46A4E-06 (326)	2.1973E-06 (326)	5.1063E-06 (243)	1.1513E-05 (243)
1.2A43E-04 (74)	1.0583E-04 (74)	9.7621E-05 (74)	8.3709E-05 (74)	7.2943E-05 (74)
7.0A11E-05 (33)	5.8301E-05 (33)	5.3622E-05 (33)	4.6085E-05 (33)	4.0243E-05 (33)
7.2407E-05 (151)	5.9259E-05 (151)	5.3899E-05 (144)	4.5A80E-05 (144)	3.9709E-05 (151)
1.5159E-04 (125)	1.2523E-04 (125)	1.1713E-04 (125)	1.0039E-04 (125)	8.7459E-05 (125)
1.0A99E-04 (65)	8.9100E-05 (65)	8.1023E-05 (65)	1.6429E-06 (216)	6.1917E-05 (65)
5.8197E-05 (175)	4.7805E-05 (175)	6.7072E-05 (221)	2.237AE-06 (366)	5.3611E-05 (221)
8.0084E-05 (111)	6.5374E-05 (111)	5.6579E-05 (111)	7.3601E-07 (142)	4.2153E-05 (111)
5.8213E-05 (113)	4.7816E-05 (113)	4.3998E-05 (113)	5.4479E-07 (304)	3.2700E-05 (113)
1.8A64E-06 (149)	1.6893E-05 (308)	1.5813E-05 (308)	3.5450E-05 (308)	3.0956E-05 (308)
3.9380E-06 (366)	1.8602E-05 (113)	1.7402E-05 (113)	5.0515E-05 (113)	4.3746E-05 (113)
2.2316E-06 (352)	1.7534E-05 (35)	1.5776E-05 (35)	2.8941E-05 (238)	2.5154E-05 (238)
2.1140E-06 (267)	1.5193E-05 (143)	1.4309E-05 (143)	5.1230E-05 (58)	4.6067E-05 (58)
5.6739E-06 (101)	1.7558E-05 (101)	1.5175E-05 (101)	4.6137E-05 (276)	4.0282E-05 (276)
8.5217E-07 (9)	7.7526E-07 (9)	6.9575E-07 (9)	6.2102E-07 (9)	5.5561E-07 (9)
7.3234E-07 (313)	5.9860E-07 (313)	4.9439E-07 (313)	4.1365E-07 (313)	3.7047E-07 (233)
6.1399E-07 (284)	5.1894E-07 (284)	4.4546E-07 (284)	3.8782E-07 (284)	3.4213E-07 (284)

Table 6-5-21

RECEPTOR ELEVATIONS FEET ABOVE MEAN SEA LEVEL

DIRECTION	0.75 Km	2.25 Km	4.5 Km	7 Km	9 Km	1.5 Km	3 Km	6 Km	8 Km	10 Km
1	7000.0	7000.0	7300.0	7000.0	7000.0	7200.0	7400.0	6800.0	7000.0	7000.0
2	7000.0	7000.0	7300.0	7000.0	7000.0	7200.0	7400.0	6800.0	7000.0	7000.0
3	7000.0	6900.0	6800.0	6700.0	6500.0	7000.0	7000.0	6800.0	6700.0	6500.0
4	7000.0	6900.0	6800.0	6700.0	6500.0	7000.0	7000.0	6800.0	6700.0	6500.0
5	7000.0	6900.0	6800.0	6700.0	6500.0	7000.0	7000.0	6800.0	6700.0	6500.0
6	7000.0	6900.0	6800.0	6700.0	6500.0	7000.0	7000.0	6800.0	6700.0	6500.0
7	7000.0	6900.0	6800.0	6700.0	6500.0	7000.0	7000.0	6800.0	6700.0	6500.0
8	7000.0	6800.0	6900.0	6600.0	6600.0	7000.0	7000.0	6700.0	6700.0	6700.0
9	7000.0	6800.0	6900.0	6600.0	6600.0	7000.0	7000.0	6700.0	6700.0	6700.0
10	7000.0	6800.0	6900.0	6600.0	6600.0	7000.0	7000.0	6700.0	6700.0	6700.0
11	7000.0	7200.0	6500.0	7100.0	6900.0	7100.0	7100.0	7000.0	7000.0	7000.0
12	7000.0	7200.0	6500.0	7100.0	6900.0	7100.0	7100.0	7000.0	7000.0	7000.0
13	7000.0	7200.0	6500.0	7100.0	6900.0	7100.0	7100.0	7000.0	7000.0	7000.0
14	7000.0	7200.0	6500.0	7100.0	6900.0	7100.0	7100.0	7000.0	7000.0	7000.0
15	7000.0	7200.0	6500.0	7100.0	6900.0	7100.0	7100.0	7000.0	7000.0	7000.0
16	7000.0	7300.0	7000.0	7400.0	7600.0	7200.0	7300.0	7000.0	7400.0	7700.0
17	7000.0	7300.0	7000.0	7400.0	7600.0	7200.0	7300.0	7000.0	7400.0	7700.0
18	7000.0	7300.0	7000.0	7400.0	7600.0	7200.0	7300.0	7000.0	7400.0	7700.0
19	7000.0	7300.0	7000.0	7400.0	7600.0	7200.0	7300.0	7000.0	7400.0	7700.0
20	7000.0	7300.0	7000.0	7400.0	7600.0	7200.0	7300.0	7000.0	7400.0	7700.0
21	7400.0	7400.0	7200.0	8000.0	8400.0	7200.0	7600.0	8000.0	8200.0	8400.0
22	7400.0	7400.0	7200.0	8000.0	8400.0	7200.0	7600.0	8000.0	8200.0	8400.0
23	7400.0	7400.0	7200.0	8000.0	8400.0	7200.0	7600.0	8000.0	8200.0	8400.0
24	7400.0	7400.0	7200.0	8000.0	8400.0	7200.0	7600.0	8000.0	8200.0	8400.0
25	7200.0	7400.0	7700.0	8000.0	7400.0	7400.0	7500.0	8000.0	8400.0	8400.0
26	7200.0	7400.0	7700.0	8000.0	7400.0	7400.0	7500.0	8000.0	8400.0	8400.0
27	7200.0	7400.0	7700.0	8000.0	7400.0	7400.0	7500.0	8000.0	8400.0	8400.0
28	7200.0	7400.0	7700.0	8000.0	7400.0	7400.0	7500.0	8000.0	8400.0	8400.0
29	7000.0	7400.0	7600.0	7800.0	8200.0	7400.0	7500.0	7600.0	7800.0	8400.0
30	7000.0	7400.0	7600.0	7800.0	8200.0	7400.0	7500.0	7600.0	7800.0	8400.0
31	7000.0	7400.0	7600.0	7800.0	8200.0	7400.0	7500.0	7600.0	7800.0	8400.0
32	7000.0	7400.0	7600.0	7800.0	8200.0	7400.0	7500.0	7600.0	7800.0	8400.0
33	7000.0	7400.0	7600.0	7800.0	8200.0	7400.0	7500.0	7600.0	7800.0	8400.0
34	7000.0	7000.0	7300.0	7000.0	7000.0	7200.0	7400.0	6800.0	7000.0	7000.0
35	7000.0	7000.0	7300.0	7000.0	7000.0	7200.0	7400.0	6800.0	7000.0	7000.0
36	7000.0	7000.0	7300.0	7000.0	7000.0	7200.0	7400.0	6800.0	7000.0	7000.0

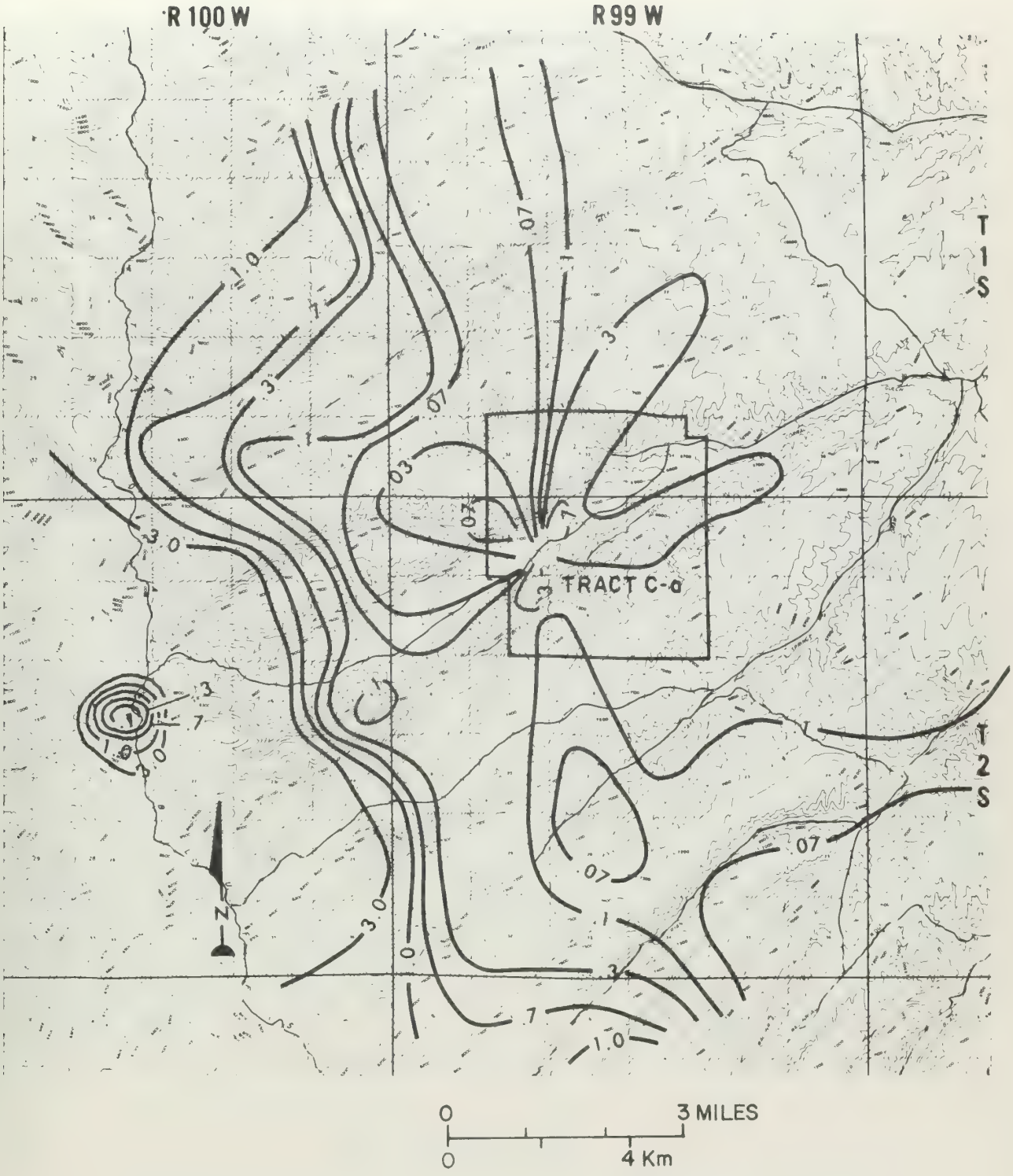


Figure 6-5-14
PREDICTED ANNUAL MEAN CONCENTRATIONS OF NO_x ($\mu g/m^3$)
MODULAR DEVELOPMENT PHASE

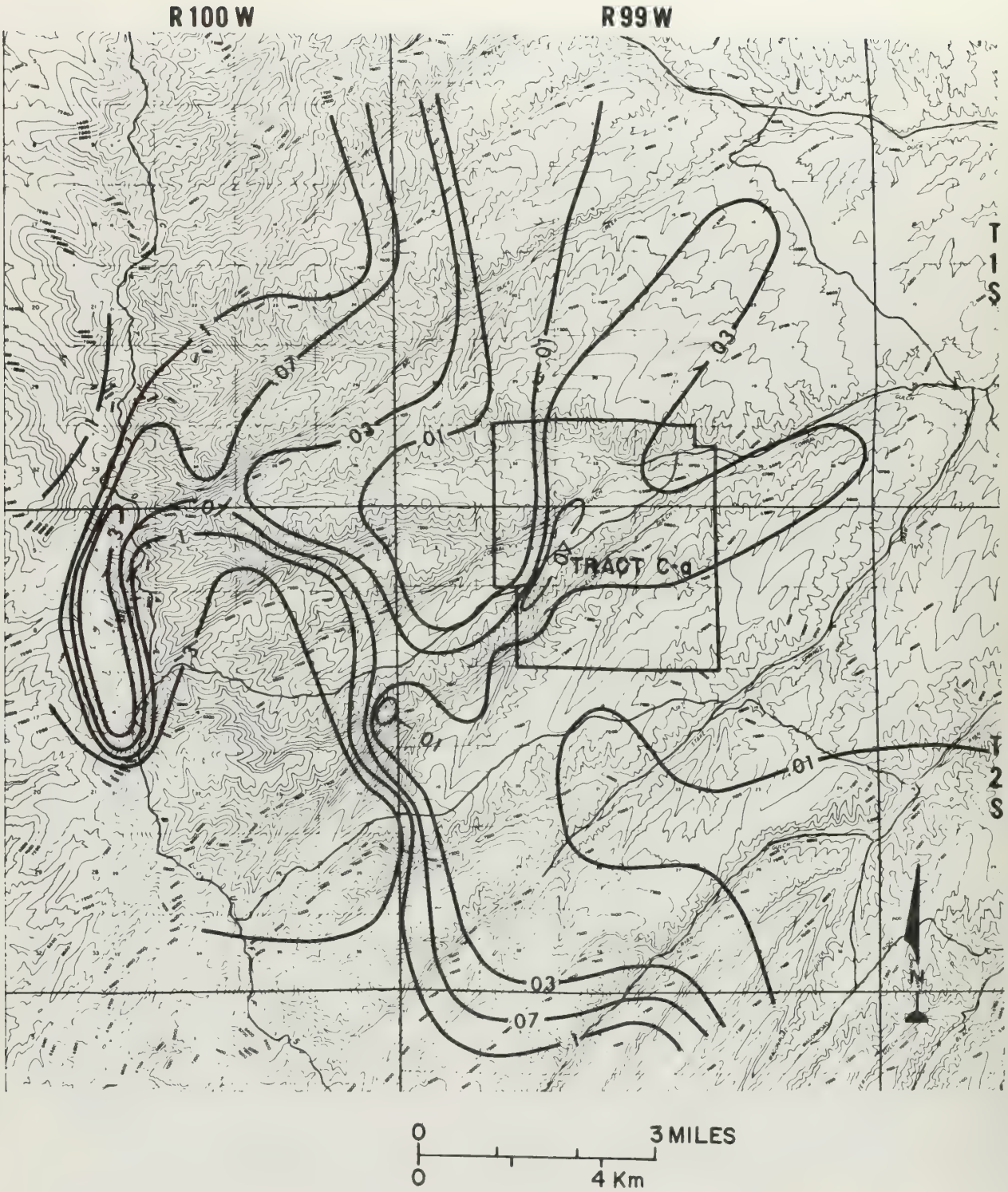


Figure 6-5-15
PREDICTED ANNUAL MEAN CONCENTRATIONS OF
SUSPENDED PARTICULATES ($\mu g/m^3$)
MODULAR DEVELOPMENT PHASE

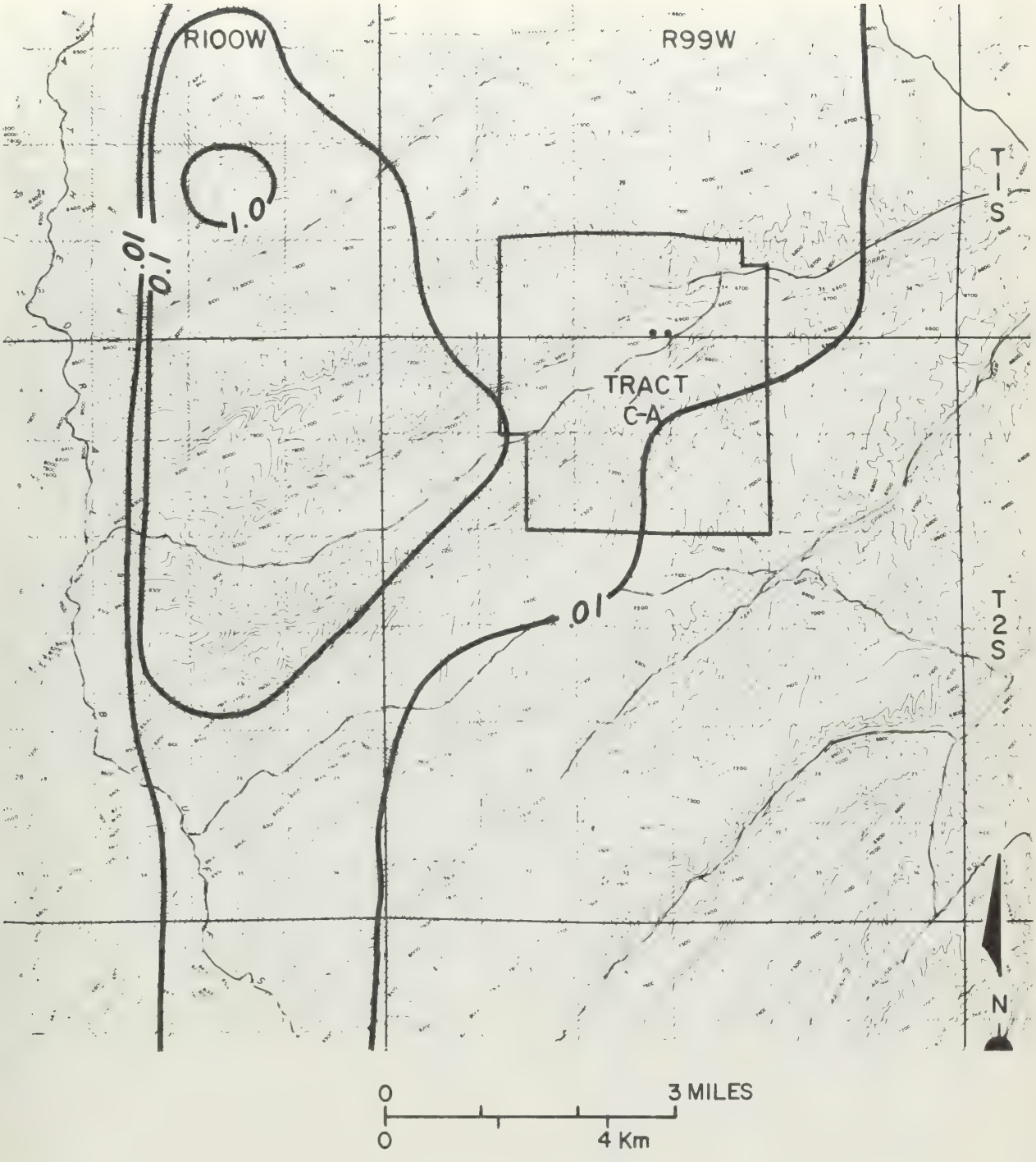


Figure 6-5-16
HIGHEST PREDICTED PARTICULATE CONCENTRATIONS ($\mu g/m^3$),
24-HOUR AVERAGE, MODULAR DEVELOPMENT PHASE
NOV. 4, 1975

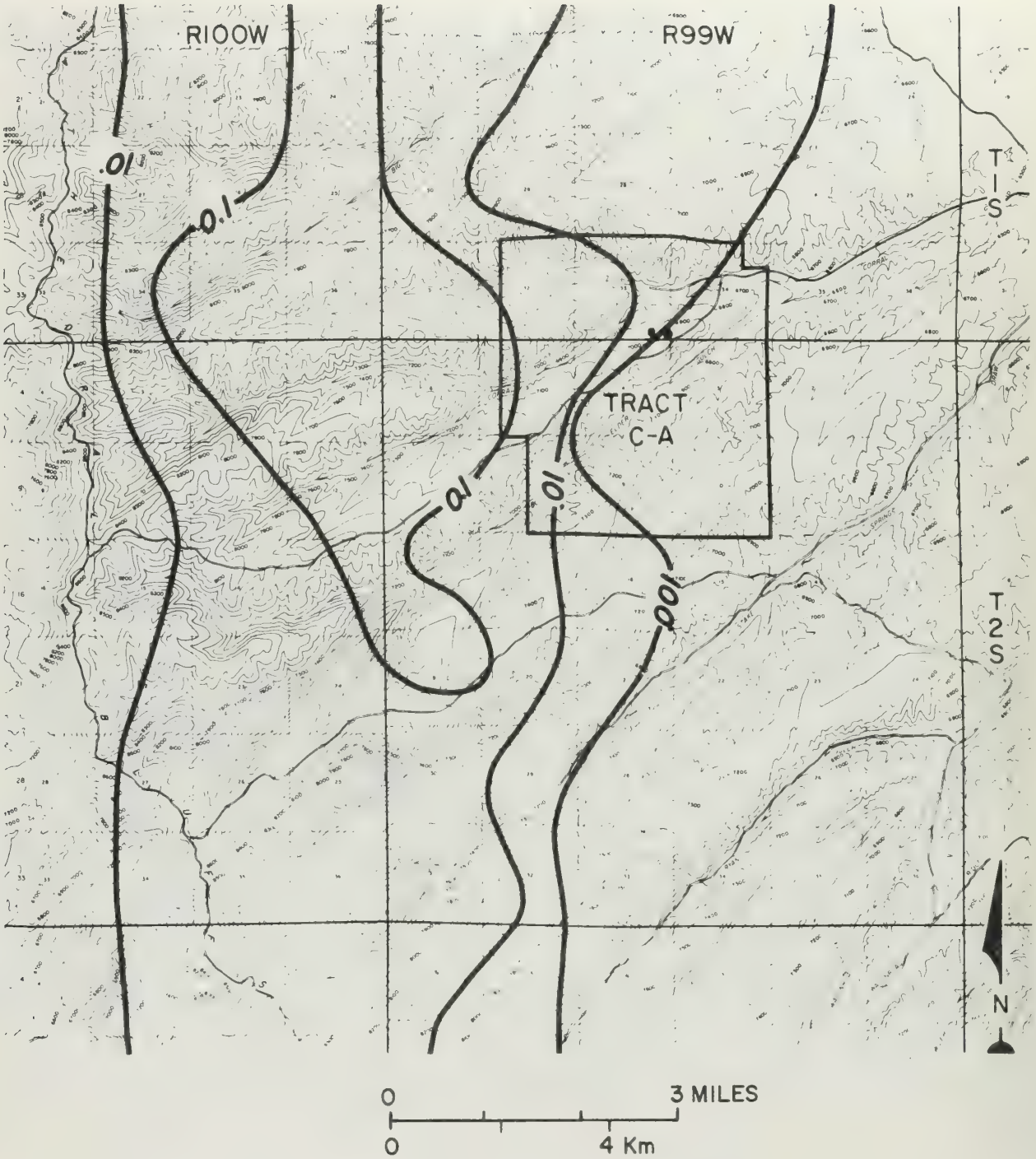


Figure 6-5-17
SECOND HIGHEST PREDICTED PARTICULATE CONCENTRATIONS ($\mu g/m^3$),
24-HOUR AVERAGE, MODULAR DEVELOPMENT PHASE
JAN. 22, 1976

4) Non-Methane Hydrocarbons - Figure 6-5-18 shows the calculated additional levels of the highest non-methane hydrocarbon ground level 3-hr. average concentrations resulting from Modular Development Phase operations. The highest predicted off-site increment is 0.3 $\mu g/m^3$. During these operations, tank farm emissions will contribute the largest part of the calculated non-methane hydrocarbon levels close to the tract. Methods of estimating tank vapor losses are imprecise. They are probably conservative when applied to the 6 a.m. - 9 a.m. time interval specified in the standards since during this time period the tanks will be relatively cool. Nonetheless, the Modular Development Phase operations will comply with the Federal non-methane hydrocarbon guidelines (Table 6-5-15).

b. Commercial Phase Operations - A summary comparison of modeling results for Commercial Phase operations with applicable standards is given in Table 6-5-22. A more detailed discussion of the modeling by individual pollutant follows. A large portion of the Modular Development Phase results discussion is applicable to the Commercial Phase, and hence only significantly different aspects are presented here.

1) Sulfur Dioxide - In general, the modeling predicts that Commercial Phase operations will meet all of the present applicable ambient air and significant deterioration standards set by the EPA. In addition, the particulate loading produced by the plant will meet the State of Colorado particulate regulations. Within the present classification of the Piceance Creek basin as Category I, the modeling analysis predicts that the proposed Commercial Phase facility will meet the current short-term ambient SO_2 standards set by the State of Colorado. However, it is doubtful that the restrictive annual average increment under Category I can be met over a period of years.

Figure 6-5-19 presents the annual average contribution from the Commercial Phase operations to the SO_2 ground level concentrations. The highest off-site predicted values are approximately 2.7 $\mu g/m^3$ about 8 km southwest

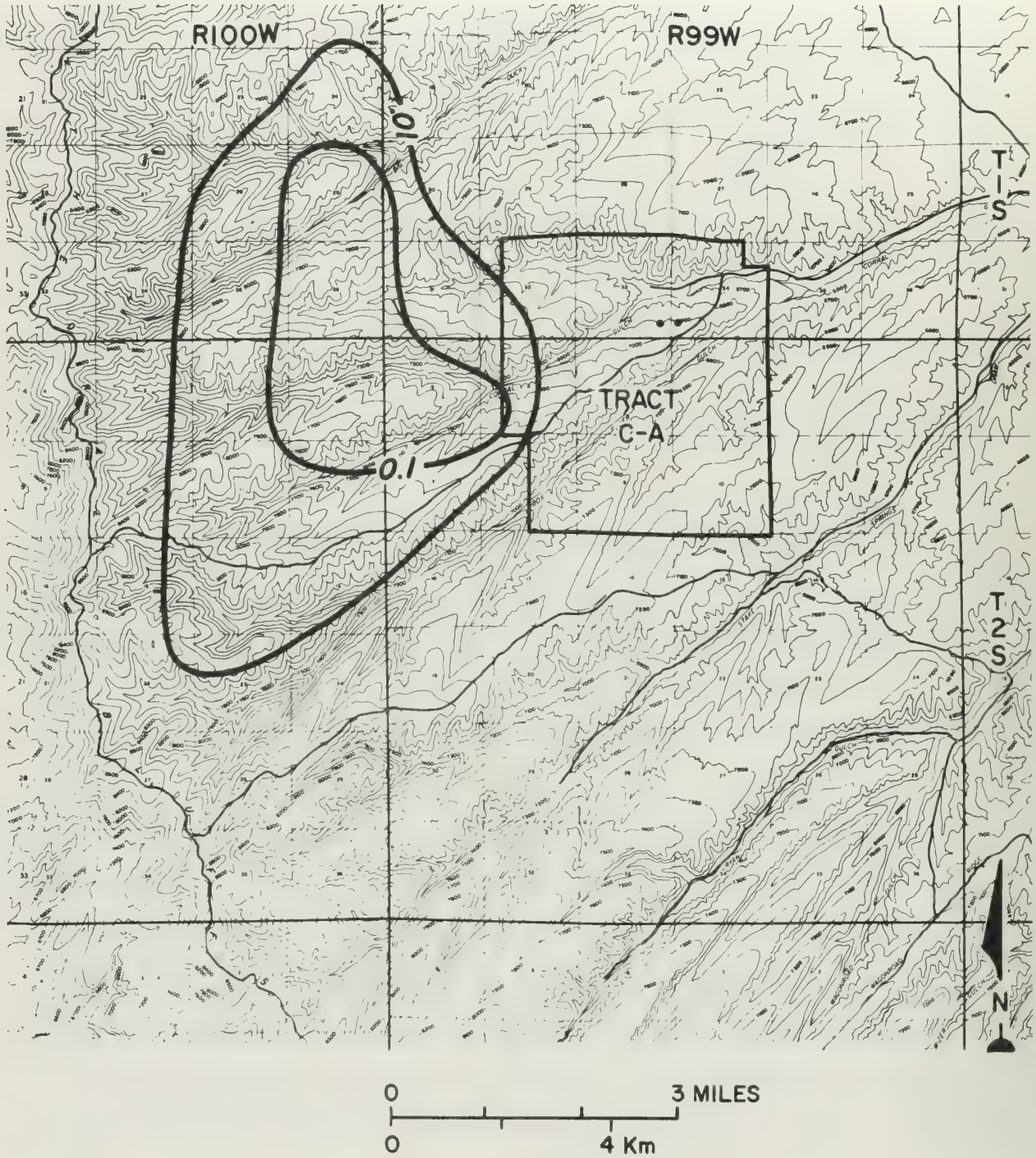


Figure 6-5-18
PREDICTED HYDROCARBON CONCENTRATIONS ($\mu g/m^3$),
3-HOUR AVERAGE, MODULAR DEVELOPMENT PHASE
NOV. 4, 1975

Table 6-5-22

COMPARISON OF MODELING RESULTS WITH APPLICABLE STANDARDS
COMMERCIAL PHASE OPERATIONS - MIS

Applicable Standard	Emission	Averaging Time	Standard Limit ($\mu g/m^3$)	Maximum Predicted Off-Site Increment Due to Development ($\mu g/m^3$)	Predicted Off-Site Value ($\mu g/m^3$)
State - Category II					
Max. allowable Increment	SO_2	Annual	15	2.7	NA
		24-hour	100	3	NA
		3-hour	700	20	NA
Federal - Class II					
Max. allowable Increment	SO_2	Annual	15	2.7	NA
		24-hour	100	3	NA
		3-hour	700	20	NA
	Particulates	Annual*	10	3**	NA
		24-hour	30	3	NA
Colorado Ambient Air Quality Standard	Particulates	Annual**	45	3**	12
		24-hour	150	3	12
National Ambient Air Quality Standards					
Primary	SO_2	Annual*	80	2.7	8
		24-hour	365	3	8
Secondary	SO_2	3-hour	1300	20	25
Primary	NO_2	Annual*	100	11	13
Primary	Particulates	Annual*	75	3**	12
		24-hour	260	3	12
Secondary	Particulates	Annual*	60	3**	12
		24-hour	150	3	12
Primary	NMHC	3-hour (6-9 AM)	160	25	90

* Geometric Mean
** Arithmetic Average
NA-Not Applicable

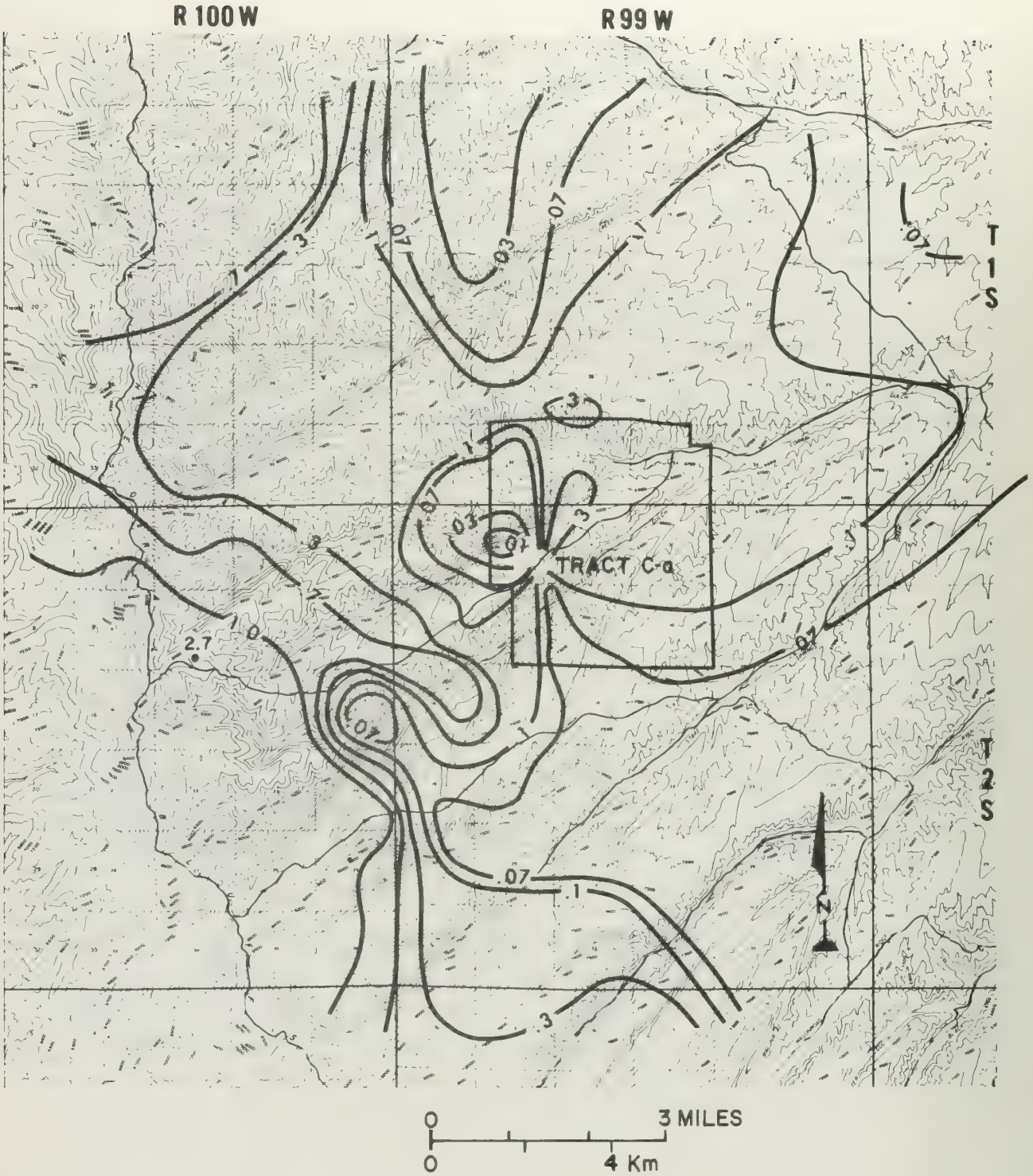


Figure 6-5-19
PREDICTED ANNUAL MEAN CONCENTRATIONS OF SO_2 ($\mu g/m^3$)
COMMERCIAL PHASE

of the facility, marginally in compliance with the Colorado Category I Standard.

The 24-hour highest and second highest SO_2 concentrations predicted from the Commercial Phase operations are shown in Figures 6-5-20 and 6-5-21. The point of maximum incremental concentration lies west and northwest of the site. The highest predicted value is 3 $\mu g/m^3$. This is well within the Category I designation of 15 $\mu g/m^3$ (Table 6-5-14). The 3-hr highest and second highest SO_2 concentrations predicted from Commercial Phase operation are shown in Figures 6-5-22 and 6-5-23. The point of maximum incremental concentrations lies at approximately the same position as the point of maximum concentration for the 24-hr maximum SO_2 concentration. The value at this point is 20 $\mu g/m^3$ compared to a Category I State standard of 75 $\mu g/m^3$.

Table 6-5-23 lists the maximum 24-hour average SO_2 concentrations and the day of occurrence predicted by CRSTER for the Commercial Phase. The meteorological data used were the Site 1 tower data and the Grand Junction upper air data for the year selected for analysis.

2) Nitrogen Dioxide - As with the Modular Development Phase operation, the annual average concentration of nitrogen dioxide from Commercial operations is within the NAASQ of 100 $\mu g/m^3$ (Table 6-5-15). The expected point of maximum annual average concentration lies southwest of the facility about 8 km. The value at this point is 11 $\mu g/m^3$ (Figure 6-5-24).

3) Particulates - Commercial Phase operations will not contribute a significant amount of dust from process operations to the ambient natural particulate loading. The predicted annual average particulate concentration increment resulting from process stack emissions is shown in Figure 6-5-25. The highest (arithmetic average) predicted off-site increment is 3.0 $\mu g/m^3$, which is much less than the Federal Class II significant deterioration standard (Table 6-5-16). As in the Modular Development

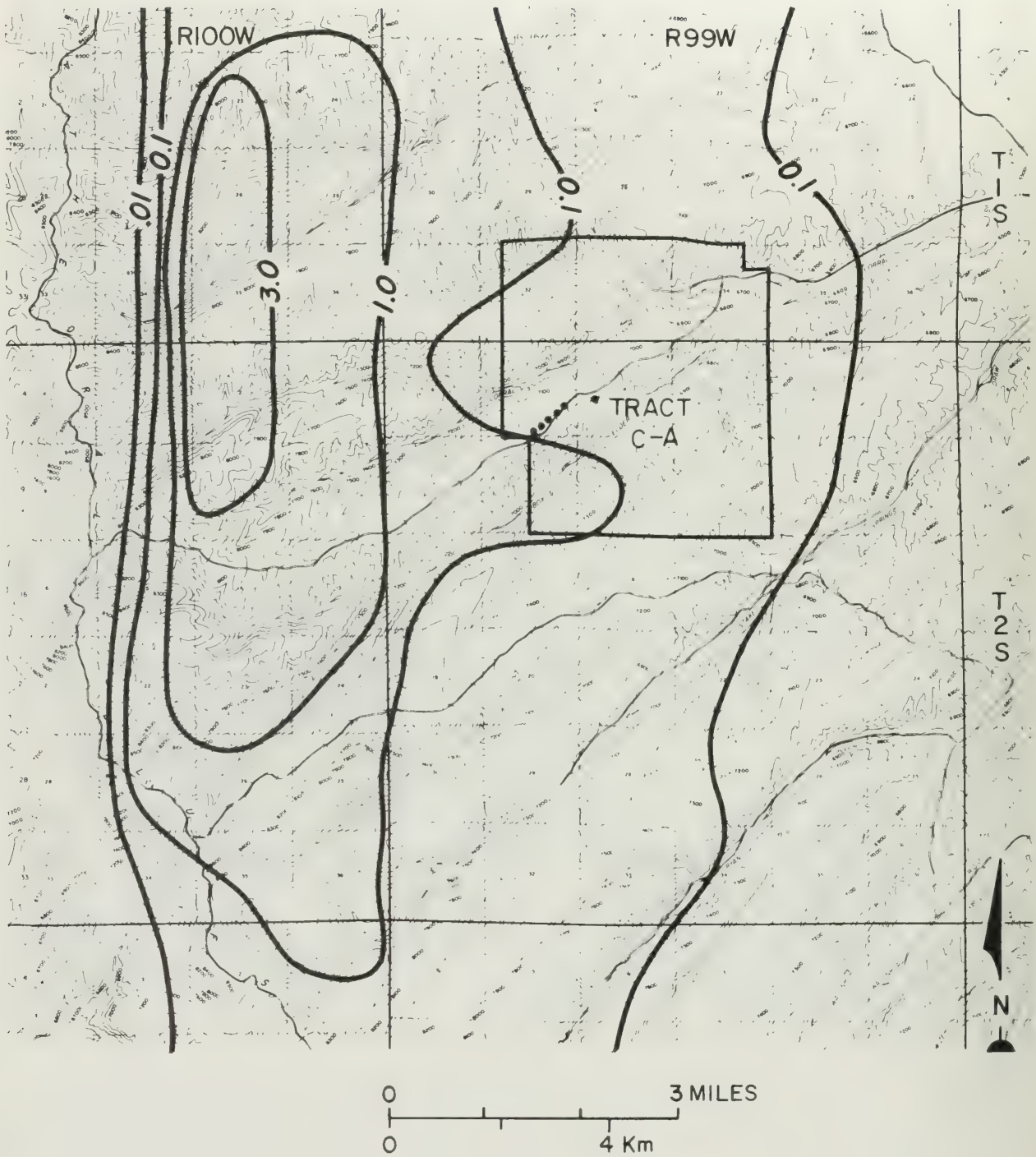


Figure 6-5-20
HIGHEST PREDICTED SO_2 CONCENTRATIONS ($\mu g/m^3$),
24-HOUR AVERAGE, COMMERCIAL PHASE
NOV. 4, 1975

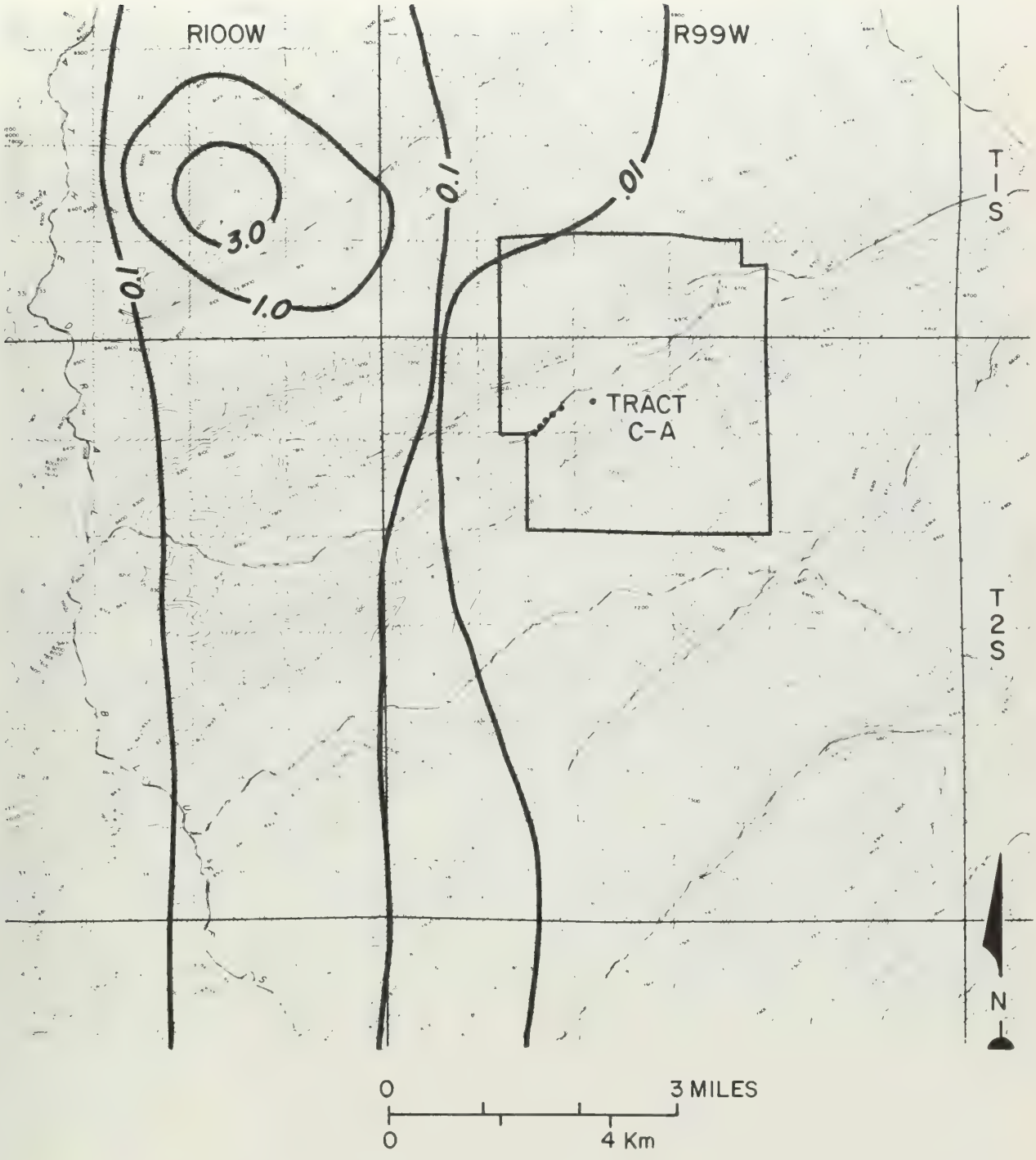


Figure 6-5-21
SECOND HIGHEST PREDICTED SO_2 CONCENTRATIONS ($\mu g/m^3$),
24-HOUR AVERAGE, COMMERCIAL PHASE
JAN. 22, 1976

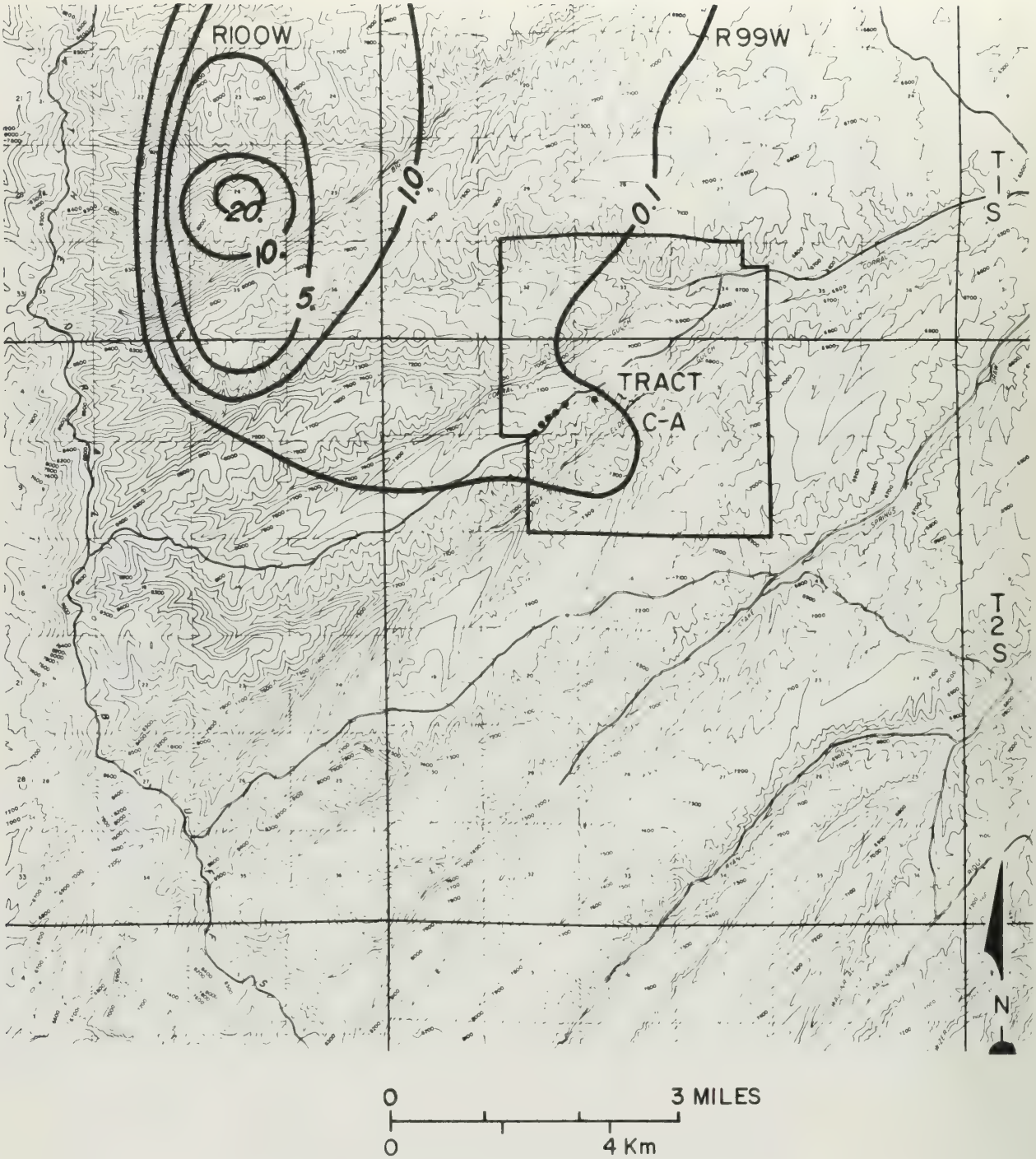


Figure 6-5-22
HIGHEST PREDICTED SO_2 CONCENTRATIONS ($\mu g/m^3$),
3-HOUR AVERAGE, COMMERCIAL PHASE
NOV. 4, 1975

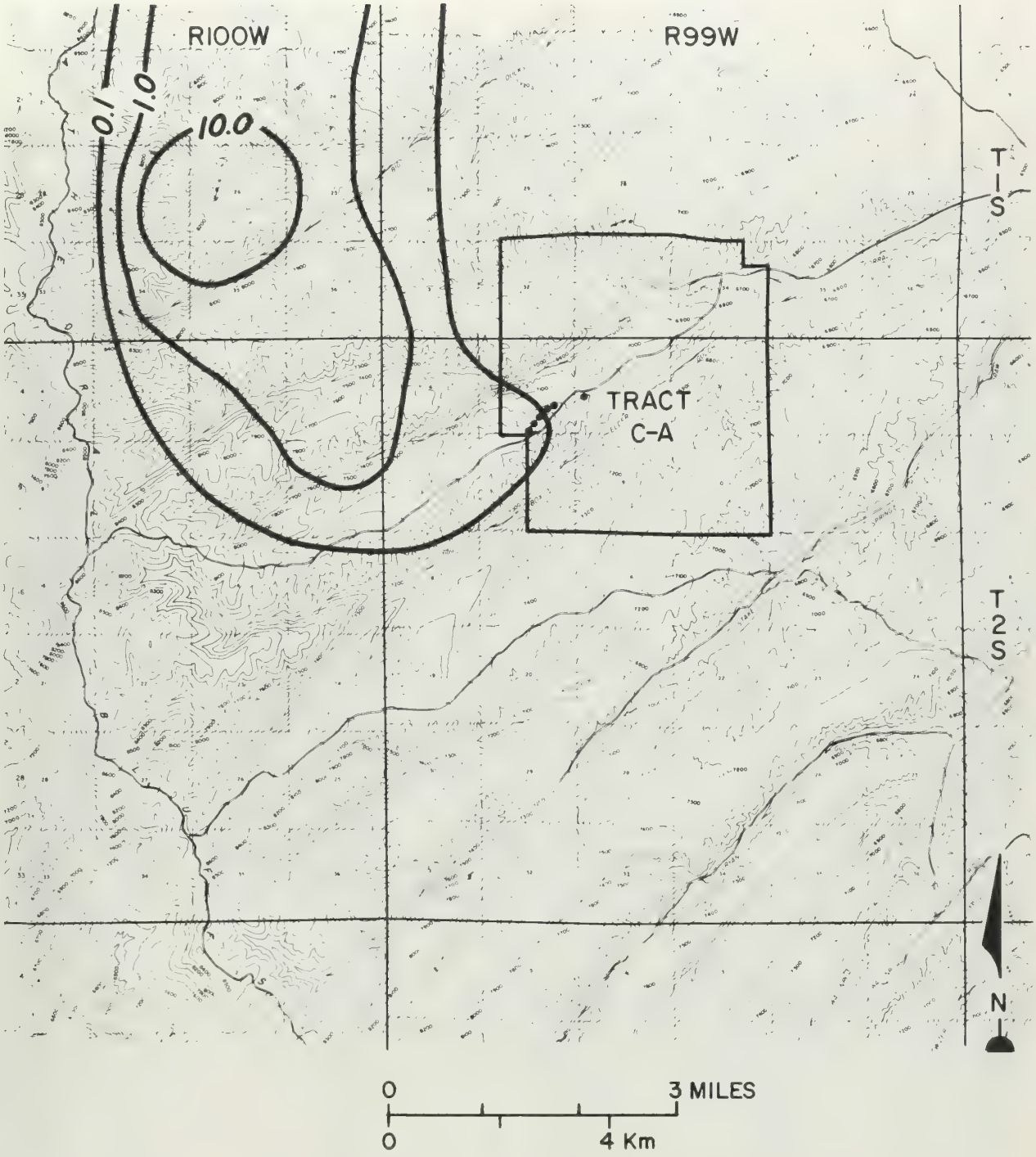


Figure 6-5-23
SECOND HIGHEST PREDICTED SO_2 CONCENTRATIONS (ug/m^3),
3-HOUR AVERAGE, COMMERCIAL PHASE
DEC. 20, 1975

Table 6-5-23

MAXIMUM 24 HOUR AVERAGE SO_2 CONCENTRATIONS
CRSTER MODEL - COMMERCIAL PHASE

DIR	RANGE 0.8 KM	1.5 KM	2.3 KM	3.0 KM	4.5 KM
1	3.9295E-06 (351)	2.2200E-06 (295)	1.7346E-06 (351)	2.5469E-06 (42)	1.1482E-06 (42)
2	7.1431E-06 (238)	4.5995E-06 (295)	2.9958E-06 (295)	3.9283E-06 (41)	2.0823E-06 (295)
3	9.9786E-06 (238)	3.7915E-06 (295)	2.5818E-06 (295)	2.2195E-06 (295)	1.6831E-06 (295)
4	7.4056E-06 (238)	2.4408E-06 (193)	1.7797E-06 (344)	1.5893E-06 (344)	1.4440E-06 (104)
5	4.6510E-06 (192)	3.4340E-06 (192)	1.9595E-06 (192)	1.4862E-06 (192)	1.0087E-06 (192)
6	5.1711E-06 (192)	3.8636E-06 (192)	2.1887E-06 (192)	1.6457E-06 (192)	1.1319E-06 (192)
7	7.6135E-06 (329)	4.1440E-06 (191)	3.1196E-06 (191)	2.5099E-06 (191)	1.9048E-06 (191)
8	1.0023E-05 (329)	5.5642E-06 (329)	3.2288E-06 (148)	2.7060E-06 (148)	1.9736E-06 (148)
9	6.6218E-06 (329)	3.5965E-06 (329)	2.0599E-06 (293)	1.9294E-06 (293)	1.5744E-06 (293)
10	3.3530E-06 (193)	2.2641E-06 (16)	1.8807E-06 (16)	1.6710E-06 (16)	1.3349E-06 (16)
11	2.7919E-06 (193)	1.5731E-06 (2)	1.5391E-06 (268)	1.2685E-06 (268)	9.9854E-07 (268)
12	2.6067E-06 (2)	1.5463E-06 (27)	1.2299E-06 (268)	1.1500E-06 (268)	9.1272E-07 (268)
13	2.3834E-06 (325)	1.5586E-06 (325)	1.2391E-06 (332)	1.0457E-06 (332)	8.3985E-07 (332)
14	5.3024E-06 (325)	3.5465E-06 (325)	1.7569E-06 (325)	1.3217E-06 (325)	8.8813E-07 (325)
15	7.3462E-06 (325)	5.1995E-06 (325)	2.6662E-06 (325)	2.0635E-06 (325)	1.4433E-06 (325)
16	5.6986E-06 (325)	3.9465E-06 (325)	2.9553E-06 (255)	2.6240E-06 (255)	1.7751E-06 (255)
17	2.7958E-06 (256)	2.0471E-06 (256)	1.9670E-06 (255)	1.7195E-06 (255)	1.2357E-06 (255)
18	4.3848E-06 (326)	2.8161E-06 (326)	1.4285E-06 (256)	1.2666E-06 (256)	9.3884E-07 (256)
19	1.1049E-05 (326)	8.0913E-06 (326)	4.4700E-06 (326)	3.5783E-06 (326)	2.2741E-06 (326)
20	1.5065E-05 (326)	1.1334E-05 (326)	6.4021E-06 (326)	4.9401E-06 (326)	3.4718E-06 (326)
21	1.1130E-05 (326)	7.7852E-06 (326)	4.1909E-06 (326)	2.9783E-05 (74)	2.1062E-06 (326)
22	5.1022E-06 (194)	2.9904E-06 (194)	2.3194E-06 (30)	1.7021E-05 (33)	1.6174E-06 (30)
23	3.5705E-06 (194)	2.2705E-06 (194)	1.8823E-06 (32)	1.7364E-05 (151)	1.0394E-06 (32)
24	5.3255E-06 (216)	4.7244E-06 (216)	3.4822E-06 (216)	3.3970E-06 (125)	1.6733E-06 (216)
25	7.1717E-06 (216)	6.7961E-06 (216)	4.6447E-06 (216)	8.5488E-06 (65)	1.6814E-05 (65)
26	5.1014E-06 (216)	4.4548E-06 (216)	2.8032E-06 (216)	6.4904E-06 (125)	1.2703E-05 (125)
27	3.5488E-06 (296)	2.7382E-06 (296)	1.6804E-06 (296)	7.6631E-06 (111)	1.3842E-05 (111)
28	2.3726E-06 (296)	1.7194E-06 (296)	1.2059E-06 (304)	5.4657E-06 (76)	9.7129E-06 (113)
29	8.9768E-07 (192)	6.4380E-07 (12)	7.7736E-07 (7)	6.4016E-06 (308)	8.4157E-06 (308)
30	8.6742E-07 (192)	1.9411E-06 (366)	1.4728E-06 (366)	6.0829E-06 (113)	1.1226E-05 (113)
31	6.6649E-07 (192)	7.8973E-07 (327)	1.0442E-06 (327)	5.8748E-06 (35)	6.8782E-06 (238)
32	5.3065E-07 (192)	4.7700E-07 (140)	8.5226E-07 (267)	5.3145E-06 (356)	9.7780E-06 (143)
33	6.1062E-07 (225)	2.4686E-06 (366)	2.3794E-06 (101)	5.9906E-06 (101)	1.0504E-05 (276)
34	1.0039E-06 (225)	9.3555E-07 (9)	8.7780E-07 (9)	1.9074E-06 (294)	7.2417E-07 (227)
35	1.3322E-06 (284)	1.1368E-06 (313)	8.5701E-07 (313)	2.0493E-06 (199)	7.4774E-07 (357)
36	2.2239E-06 (224)	1.3240E-06 (284)	1.0372E-06 (284)	1.7106E-06 (227)	7.3631E-07 (227)

	6.0 KM	7.0 KM	8.0 KM	9.0 KM	10.0 KM
	9.3400E-07 (351)	8.4048E-07 (351)	7.6283E-07 (351)	6.9677E-07 (351)	6.3973E-07 (351)
	1.4701E-06 (295)	1.3138E-06 (295)	1.1819E-06 (295)	1.0744E-06 (295)	9.8500E-07 (295)
	1.3170E-06 (295)	1.1388E-06 (295)	1.0265E-06 (162)	9.7530E-07 (162)	9.3499E-07 (162)
	1.3260E-06 (104)	1.2215E-06 (104)	1.1220E-06 (104)	1.0330E-06 (104)	9.5595E-07 (104)
	8.2283E-07 (127)	7.5023E-07 (127)	6.8872E-07 (127)	6.3863E-07 (127)	5.9794E-07 (127)
	8.6067E-07 (192)	7.5164E-07 (103)	6.8731E-07 (103)	6.3042E-07 (103)	5.8275E-07 (103)
	1.5715E-06 (191)	1.4131E-06 (191)	1.2874E-06 (191)	1.1856E-06 (191)	1.1014E-06 (191)
	1.5504E-06 (148)	1.3604E-06 (148)	1.2144E-06 (148)	1.0986E-06 (148)	1.0052E-06 (148)
	1.2927E-06 (293)	1.1448E-06 (293)	1.0174E-06 (293)	9.0818E-07 (293)	8.1527E-07 (293)
	1.0631E-06 (16)	9.1406E-07 (16)	7.9038E-07 (16)	6.8909E-07 (16)	6.0653E-07 (16)
	7.4804E-07 (268)	6.5546E-07 (268)	5.5135E-07 (268)	4.7968E-07 (268)	4.4341E-07 (268)
	7.0841E-07 (268)	6.4247E-07 (268)	5.3521E-07 (268)	4.6326E-07 (268)	4.3499E-07 (268)
	7.0957E-07 (332)	6.3274E-07 (332)	5.6448E-07 (332)	5.0505E-07 (332)	4.5385E-07 (332)
	6.9724E-07 (242)	6.3752E-07 (242)	5.4499E-07 (242)	4.7332E-07 (242)	4.3303E-07 (242)
	1.1207E-06 (325)	9.7899E-07 (325)	8.7096E-07 (325)	7.8574E-07 (325)	7.1668E-07 (325)
	1.2590E-06 (255)	1.8990E-06 (47)	1.7949E-06 (47)	4.9101E-06 (347)	5.6267E-06 (347)
	9.1751E-07 (255)	2.7646E-06 (359)	2.5541E-06 (359)	5.3157E-06 (359)	6.7666E-06 (359)
	6.9597E-07 (256)	1.6701E-06 (22)	1.5739E-06 (22)	3.3530E-06 (22)	4.2632E-06 (61)
	1.7135E-06 (326)	1.5324E-06 (79)	1.4486E-06 (79)	3.8395E-06 (275)	4.4074E-06 (275)
	2.6979E-06 (326)	2.6218E-06 (243)	2.3992E-06 (243)	6.1784E-06 (143)	7.1453E-06 (143)
	3.4883E-05 (74)	3.1289E-05 (74)	8.9837E-05 (74)	8.7883E-05 (74)	7.6406E-05 (74)
	1.9669E-05 (33)	1.7753E-05 (33)	5.0461E-05 (33)	4.8273E-05 (33)	4.2152E-05 (33)
	2.5680E-05 (151)	2.3238E-05 (151)	4.9805E-05 (151)	4.8039E-05 (144)	4.1615E-05 (151)
	4.1567E-05 (125)	3.7249E-05 (125)	1.0422E-04 (125)	1.0514E-04 (125)	9.1613E-05 (125)
	2.4066E-05 (65)	2.0435E-05 (65)	8.4948E-05 (65)	1.6034E-06 (216)	6.4955E-05 (65)
	2.0472E-05 (125)	1.8472E-05 (125)	7.0271E-05 (221)	2.1129E-06 (125)	5.6169E-05 (221)
	2.9022E-05 (111)	2.6378E-05 (111)	5.9264E-05 (111)	1.7015E-06 (111)	4.4154E-05 (111)
	2.5039E-05 (76)	2.1973E-05 (76)	4.6086E-05 (113)	1.4500E-06 (304)	3.4252E-05 (113)
	6.0902E-06 (308)	9.1422E-06 (308)	7.8848E-06 (308)	3.7133E-05 (308)	3.2425E-05 (308)
	7.9752E-06 (113)	1.1065E-05 (113)	9.4351E-06 (113)	4.4635E-05 (113)	4.5822E-05 (113)
	8.8477E-06 (238)	7.5802E-06 (35)	6.5415E-06 (35)	3.0315E-05 (238)	2.6348E-05 (238)
	7.0910E-06 (58)	1.2231E-05 (58)	1.0806E-05 (58)	5.2971E-05 (58)	4.8254E-05 (58)
	7.4778E-06 (276)	1.0918E-05 (276)	9.3383E-06 (276)	4.4161E-05 (276)	4.2194E-05 (276)
	4.8585E-07 (227)	4.7144E-07 (227)	4.5022E-07 (227)	4.2872E-07 (227)	4.0784E-07 (227)
	4.8963E-07 (313)	4.3203E-07 (313)	3.7965E-07 (313)	3.5863E-07 (357)	3.4041E-07 (357)
	5.0124E-07 (284)	4.2838E-07 (284)	3.7128E-07 (284)	3.2671E-07 (284)	2.9445E-07 (39)

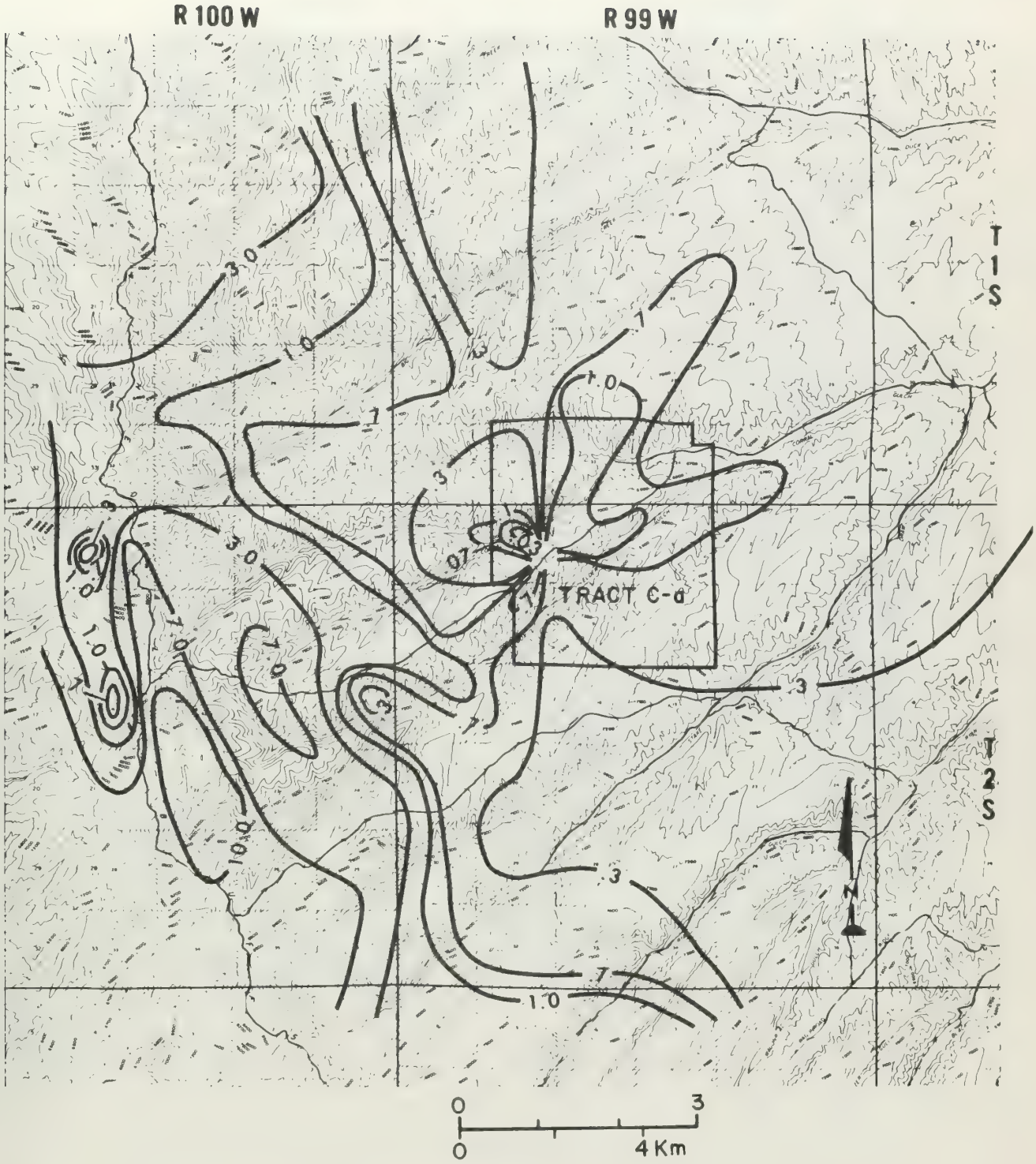


Figure 6-5-24
PREDICTED ANNUAL MEAN CONCENTRATIONS OF NO_x ($\mu g/m^3$)
COMMERCIAL PHASE

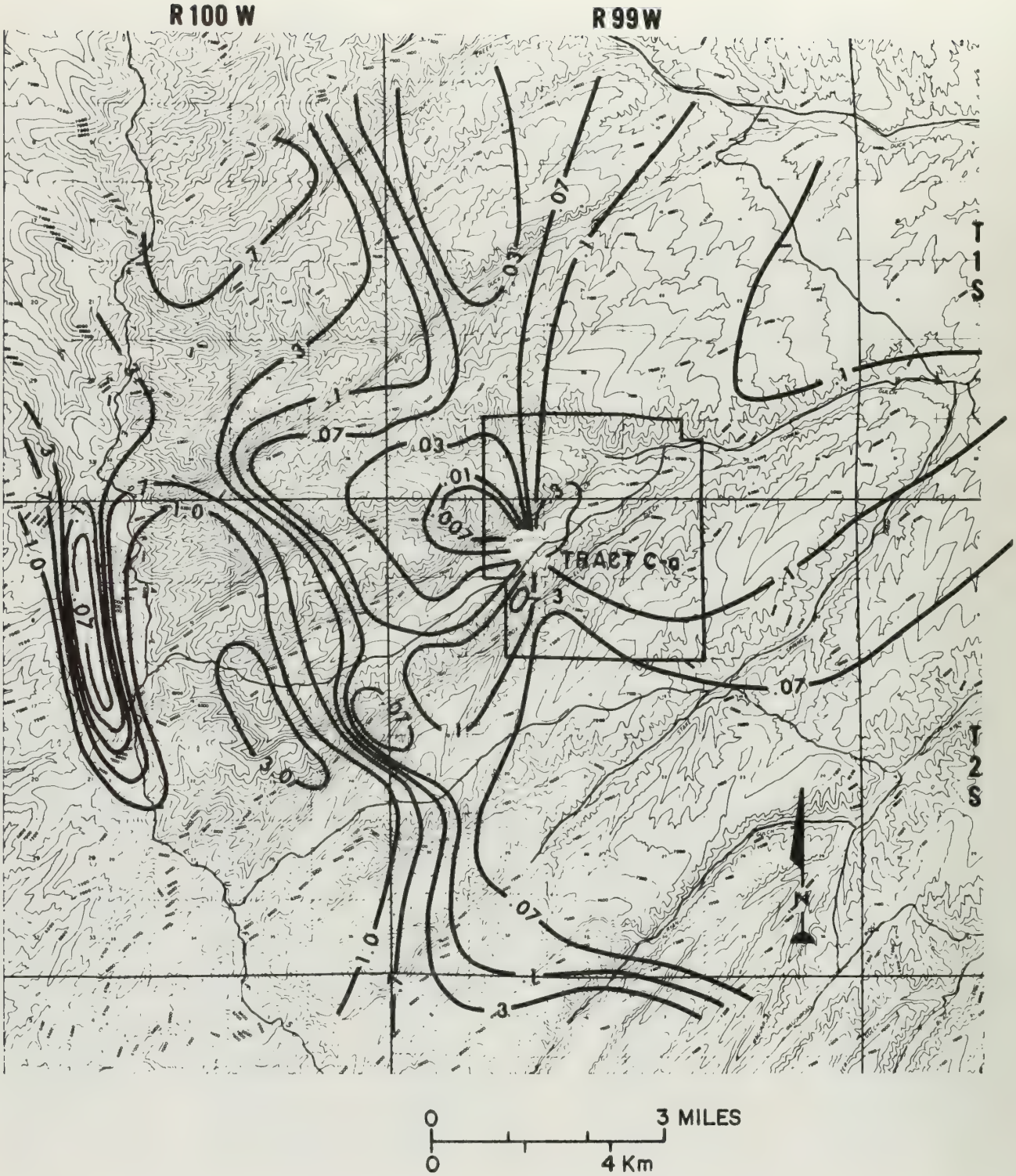


Figure 6-5-25
PREDICTED ANNUAL MEAN CONCENTRATIONS OF
SUSPENDED PARTICULATES ($\mu g/m^3$)
COMMERCIAL PHASE
6-5-76

Phase discussion, the Federal standard is for an annual geometric mean whereas the results of the modeling predictions are expressed as an arithmetic mean. Geometric mean concentrations are always less than the arithmetic mean, typically by a factor of 0.6 to 0.7.

Therefore, it is apparent that the particulate increments will be within presently applicable standards. The expected 24-hr highest and second highest increments in ground level particulate concentration from these operations for the year of data examined are presented in Figures 6-5-26 and 6-5-27. The maximum increments of particulates off-site are about 3 $\mu g/m^3$ compared to the Federal Class II non-deterioration regulation of 30 $\mu g/m^3$ for a 24-hr maximum (Table 6-5-16).

4) Non-Methane Hydrocarbons - Figure 6-5-28 shows calculated additional levels of the highest non-methane hydrocarbon ground level 3 hr average concentration resulting from Commercial Phase operations. The highest predicted off-site increment is 25 $\mu g/m^3$. This will comply with the National Ambient Air Quality guideline of 160 $\mu g/m^3$ (Table 6-5-15). During these operations, the elevated emissions will contribute the largest part of the calculated non-methane hydrocarbon levels close to the tract.

c. Fumigation Modeling - Fumigation conditions were modeled in order to ensure that they do not define worst case short-term conditions. Fumigation occurs when a plume is released into a thermally stable atmosphere where it is transported downwind as a narrow flat ribbon. Its horizontal rate of spread is only slightly reduced from a more unstable case; however, the vertical dispersion is at a minimum. As the stable layer "burns off," thermally induced vertical mixing develops upward from the ground. When the elevated inversion reaches the level of the plume, high concentrations of pollutants are brought to ground level, being mixed within the entire height interval from the elevation of the mixing layer to the surface.

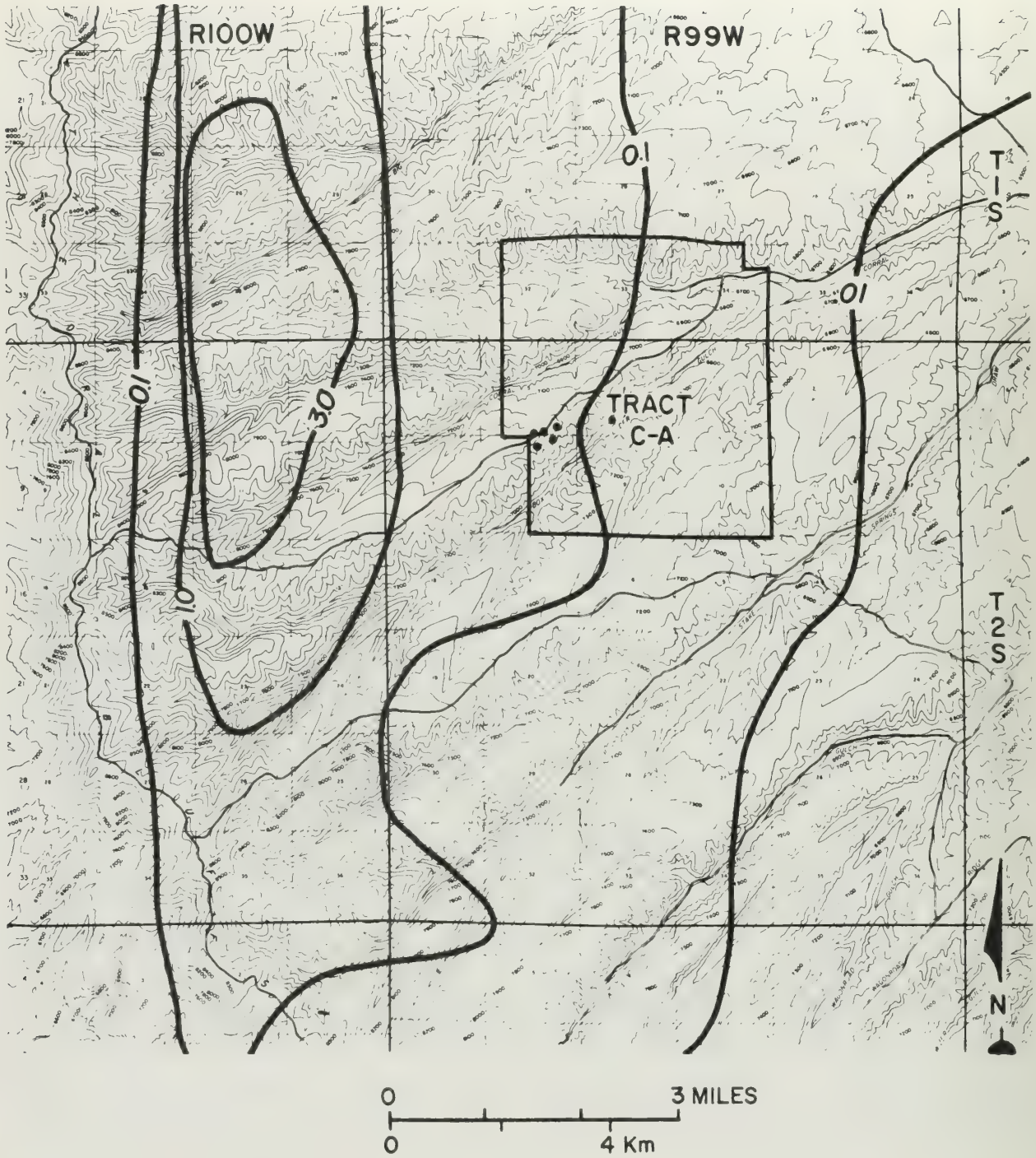


Figure 6-5-26
HIGHEST PREDICTED PARTICULATE CONCENTRATIONS ($\mu g/m^3$),
24-HOUR AVERAGE, COMMERCIAL PHASE
NOV. 4, 1975

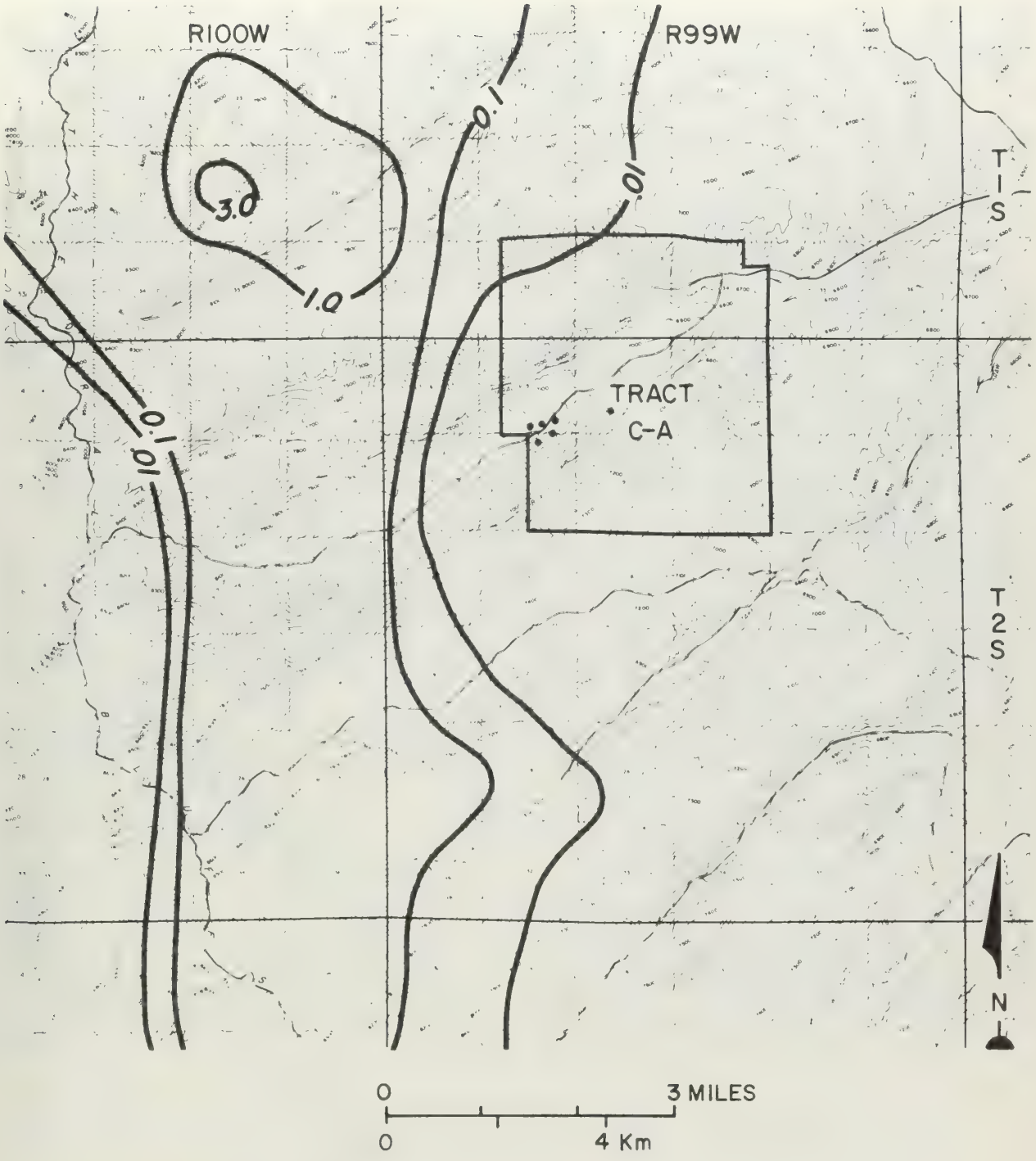


Figure 6-5-27
SECOND HIGHEST PREDICTED PARTICULATE CONCENTRATIONS ($\mu g/m^3$),
24-HOUR AVERAGE, COMMERCIAL PHASE
JAN. 22, 1976

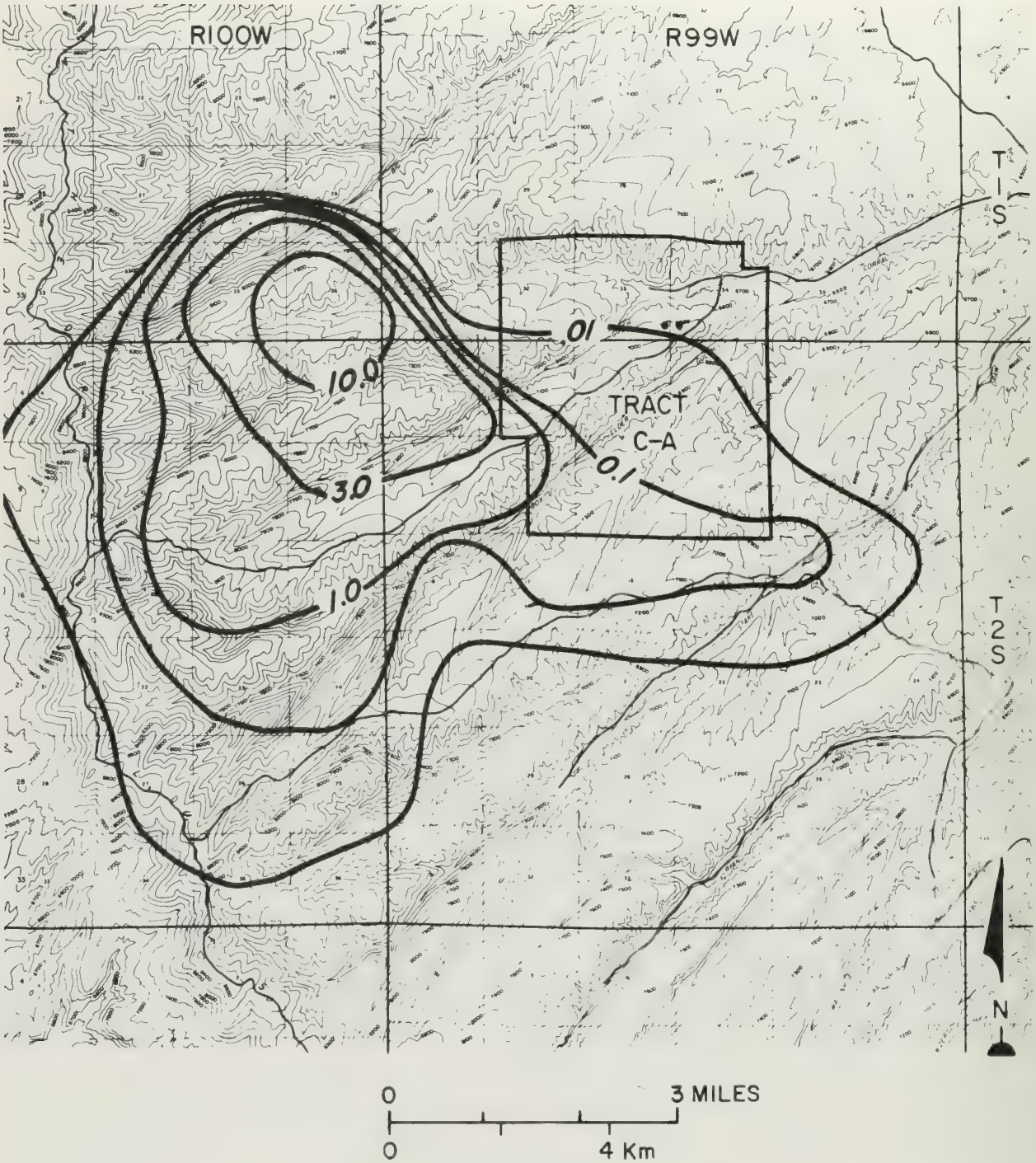


Figure 6-5-28
PREDICTED HYDROCARBON CONCENTRATIONS ($\mu g/m^3$),
3-HOUR AVERAGE, COMMERCIAL PHASE
NOV. 4, 1975

Because the emission sources will reach different absolute elevations, and because the plumes from each of these sources will reach different heights above the surface during a fumigation episode, prediction of these episodes is difficult. This phenomena is a transitory one, not steady-state. Because of this rapidly changing situation, the predicted concentration from a fumigation episode would not be expected to last more than approximately 1 hr.

The fumigation model used by the Tennessee Valley Authority (Montgomery, 1973) was used to predict concentrations of SO_2, NMHC, and particulates. The final absolute elevation of each of the plumes was calculated taking into account the stack height and the plume rise. The final plume rise height was calculated using Brigg's equations (Briggs, 1970). The distances of maximum concentration and the maximum concentration for each time the mixing layer penetrated to the heights of these different plumes was then calculated according to:

$$X_{max} = u\rho C_p (H_f^2 - H_s^2)/4K$$

and

$$X = \frac{Qx10^6}{1.1 \sqrt{2\pi}\, \sigma_{yf} H_f u}$$

X = maximum concentration (5 minute average), ($\mu g/m^3$)

σ_{yf} = horizontal dispersion parameter = σ_y + 0.47 H, (m)
where σ_y = horizontal dispersion parameter and stable conditions

H_f = height of plume top prior to fumigation, (m)

u = 3 m/s = suggested minimum velocity to give worst case concentrations

K = eddy heat conductivity = 8×10^3 cal/(m^oK sec)

ρ = air density at 7000 ft MSL

C_p = specific heat of air = 0.24

H = stack height + plume rise

Q = emission rate (g/s)

The time for the mixing layer to reach this altitude, H, is given by:

$$t \text{ (seconds)} = \frac{X_{max}}{u}$$

Using the source parameters shown in Tables 6-5-17 and 6-5-18, the maximum concentrations of pollutants were calculated.

For the Modular Development and Commercial Phases, the predicted fumigation concentration for all pollutants are less than that estimated by worst-case dispersion modeling when the concentration from a 1-hour fumigation episode is proportioned over the 3-hour and 24-hour intervals specified by the regulations.

d. Fugitive Particulate Emissions and Air Quality Impact - The air quality impact of potential fugitive dust emissions has been estimated. Dust emissions from the material handling operations were considered here as well as vehicular generated road dust. The estimated emissions used for the analysis are summarized in Table 6-5-24 for Modular Development Phase operations, in Table 6-5-25 for operations during the initial stages of period of Commercial construction operation (1985-1986), and in Table 6-5-26 for the Commercial Phase (after 1986) (USEPA, 1975; Axetell and Zimmer, 1975; Cowherd, 1974).

Table 6-5-24

SUMMARY OF EMISSIONS DURING MODULAR DEVELOPMENT PHASE (1978-1985)

	Operation	Estimated* Emissions W/Control (lb./hr.)	Applicable Dispersion Equation
Source A	Loadout Emissions	8.94	1
Source F	Disposal Operations	5.36	3

* Estimates are for peak emission rates

Table 6-5-25

SUMMARY OF EMISSIONS DURING CRUSHED ORE DISPOSAL OPERATIONS
(1985-1986)

	Operation	Estimated Emissions W/Control (lb./hr.)	Applicable Dispersion Equation
Source A	Ore Receipt and Transfer		1
	Feeder Transfer	.19	
	Overland Conveyor Transfer Points	.36	
Source D	Disposal Operations		3
	Mobile Equipment Operations	10.4	
Source E	Truck Loadout	.19	1

* Estimates are for peak emission rates.

Table 6-5-26

SUMMARY OF EMISSIONS DURING THE COMMERCIAL PHASE
(After 1986)

	Operation	Estimated Emissions with Control* (lb/hr)	Applicable Dispersion Equation
Source A	Ore Receipt and Transport		1
	Feeder Transfer	.19	
	Overland Conveyor Transfer Points	.12	
Source B	Primary Storage and Reclaim		2
	Mobile Reclaim Equipment	.50	
	Primary Crushed Ore Stockpile	1.95	
	Primary Crushed Ore Reclaim	.75	
	Reclaimed Ore Transfer Points	0.15	
Source C	Secondary Crushing and Screening		2
	Feedstock Preparation Plant	22.90	
	Receipt Transfer Points	.15	
	Feedstock Storage and Sampling System		
	Storage Bin Transfer Points	.15	
	Reserve Storage Transfer Points	.30	
	Reserve Storage	1.12	
	Mobile Reclaim Equipment	.50	
	Reserve Storage Reclaim	.75	
	Emergency Unloading Transfer Points	.40	
	Feedstock Reclaim Transfer Points	.60	
	Retorts, Processed Shale Receipt and Transport		
	Retort Receiving Bins	.12	
Source D	Disposal Operations		3
	Mobile Equipment Operations	11.01	

* Estimates are for peak emission rates.

As indicated in Tables 6-5-24 through 6-5-26, several of the individual sources have been combined in this study and are considered as area sources. For conservatism and to simplify the analysis, emissions from overland conveyor transfer points were considered to occur at a central location. Since these emissions are minimal, the effect on the air quality impact analysis is considered insignificant. Also, operations were assumed to occur 24 hr per day and 7 days per week for the air quality impact analysis.

The emission terms presented in Tables 6-5-24 through 6-5-26 are based on use of particulate controls. A wet suppression system will be used to control dust generated by ore transportation. Baghouses will be used for the material preparation and feedstack storage systems. A lowering tube will be used to ease the fall of material to the primary crushed ore stockpile and a telescopic spout will be used at the reserve storage facility. All conveyors will be hooded to retard dust generation. Disposal areas, haulage roads, and unpaved areas will be watered to reduce vehicular generated particulate emissions.

The maximum 24-hr concentrations of suspended particulates were estimated for the various emission sources using the sector average Gaussian dispersion model, which is described by Equations 1 and 2. For line sources, the finite line source Gaussian dispersion model described by Equation 3 is used. Concentrations based on point sources were computed using Equation 1. Computations using Equation 2 are adjusted to reflect an area source emisssion by assuming a vertical point source at -200 m. [The virtual source distance is the adjustment made such that the "initial" plume width corresponds to the width (250 ft for this analysis) of the area source.] The effect of this approach is to reduce concentrations near the source (within a few kilometers) but effects at large distances are insignificant. Equation 3 was used to compute concentrations for a finite line source when the wind flow is at a 45° angle to the line.

$$X = \frac{2.032\ QF}{\sigma_z\ \bar{u}\ x} \qquad \text{Equation 1}$$

$$X = \frac{2.032\ QF}{\sigma_x \bar{u}\ (x+x')} \qquad \text{Equation 2}$$

$$X = \frac{2\ QF}{\sigma_z \bar{u} \sqrt{2\pi}\ \text{Sin}\ 45^o} \int_{p_1}^{p_2} \frac{1}{\sqrt{2\pi}} \exp\ (-.5\ p^2) dp \qquad \text{Equation 3}$$

where:

X = concentration, $\mu g/m^3$
Q = source term emission rate, µg/sec for Equations 1 and 2, µg/sec per m for Equation 3
F = fraction of total time that stability class i occurs for sector of interest
$\bar{u}$ = mean wind speed for stability class i, m/sec
x = downwind distance, m
x' = virtual source distance, m
σ_z = vertical dispersion parameter for stability class i, m
σ_y = horizontal dispersion parameter for stability class i, m
p_1 = y_1/σ_y
p_2 = y_2/σ_y
y = limits of the line source, m

The meteorological conditions which were used as input to Equation 1 for calculating maximum 24-hr concentrations are "E" stability associated with 2 m/sec winds which persist in one 22.5 degree sector for 24 hr. These meteorological conditions were selected to represent poor dispersion conditions which have a low probability of occurrence. However, these conditions were postulated based on a qualitative examination of onsite meteorological data for the period September 1975-August 1976, and by consideration of an actual period of high wind direction persistence associated with relatively low wind speeds and stable conditions.

The results of 24-hr concentration calculations are presented in Table 6-5-27. Compared to the applicable air quality standards and considering

TABLE 6-5-27

SUMMARY OF MAXIMUM 24-HOUR PARTICULATE CONCENTRATIONS* ($\mu g/m^3$)

Downwind Distance (m)	Commercial Operation (after 1986) Source				CRUSHED ORE DISPOSAL OPERATIONS (1985-1986) Source			Modular Develop. Phase (1978-1985) Source	
	A	B	C	D	A	D	E	A	F
100	115	420	3,350	250	200	230	71	3,340	120
200	31	170	1,340	140	60	130	19	890	66
500	6	45	360	62	10	58	4	170	30
1,000	2	16	120	37	3	35	1	50	18
2,000	1	6	40	24	1	22	<1	16	11
5,000	<1	2	11	13	<1	13	<1	4	7
10,000	<1	<1	4	8	<1	7	<1	1	5
20,000	<1	<1	2	3	<1	3	<1	1	4
50,000	<1	<1	1	1	<1	1	<1	<1	3

*Values do not include background level.

background level of particulates, 9-10 $\mu g/m^3$, computed concentrations are within acceptable limits beyond 2-5 km downwind of the sources for site development and commercial operations. (Applicable air quality standards have been summarized in Tables 6-5-14 and 6-5-16.

Annual suspended particulate air concentrations have been computed using Equation 4 for point sources and Equation 5 for area sources and based on onsite meteorological data for the period September 1975-August 1976 corrected for area source. Atmospheric stability was based on $\Delta T_{(60m-10m)}$ from Site 1 and wind data were based on 10-m data from Site 2.

$$X = \frac{2.032\ Q}{x} \sum_{i=1}^{7} \sum_{j=1}^{7} \frac{F_{ij}}{\sigma_{z_i}\ \bar{u}_j} \qquad \text{Equation 4}$$

$$X = \frac{2.032\ Q}{(x + x')} \sum_{i=1}^{7} \sum_{j=1}^{7} \frac{F_{ij}}{\sigma_{z_i}\ \bar{u}_j} \qquad \text{Equation 5}$$

where:

F_{ij} = relative frequency of wind speed group "j" associated with stability class "i", for sector of interest

$\bar{u}_j$ = midpoint of wind speed class range

The results of annual calculations are presented in Table 6-5-28 for the maximum affected sector (east). Compared to the applicable air quality standards and considering the background level of particulates, 9-10 $\mu g/m^3$, computed concentrations are within acceptable limits at a downwind distance of 1-2 km for modular development and commercial operations. Estimates were not calculated for emissions generated by mobile equipment. However, considering the control measures to be used for these emissions, it is anticipated that concentrations due to mobile equipment will also be within acceptable limits.

TABLE 6-5-28

SUMMARY OF ANNUAL AVERAGE PARTICULATE CONCENTRATIONS* ($\mu g/m^3$)

Downwind Distance (m)	Commercial Operation (after 1986) Source A	B	C	D	CRUSHED ORE DISPOSAL OPERATIONS (1985-1986) Source A	D	E	Modular Develop. Phase (1978-1985) Source A	F
100	16	56	453	NC	27	NC	3	457	NC
200	4	22	186	NC	8	NC	1	123	NC
500	1	6	49	NC	1	NC	<1	23	NC
1,000	<1	2	18	NC	<1	NC	<1	7	NC
2,000	<1	<1	6	NC	<1	NC	<1	2	NC
5,000	<1	<1	2	NC	<1	NC	<1	1	NC
10,000	<1	<1	1	NC	<1	NC	<1	<1	NC
20,000	<1	<1	<1	NC	<1	NC	<1	<1	NC
50,000	<1	<1	<1	NC	<1	NC	<1	<1	NC

NC - Not calculated for this analysis.

*Values do not include background level.

e. Mine Ventilation Emissions and Associated Air Quality Impact - The air quality impact of vent emissions has been estimated. Emission factors and other source input data used for the dispersion analysis are summarized in Table 6-5-29.

Table 6-5-29

VENT RELEASE SOURCE TERMS

Vent Height	15.3 m
Vent Diameter	12.6 m
Exit Velocity	15.3 m/sec
Exit Temperature	31^{o} C
NO_x Emission Rate	0.83×10^{8} µg/sec
CO^x Emission Rate	1.03×10^{8} µg/sec

Short term (1-hour and 8-hour) concentrations for CO were computed using the computer program CONCAP. Dispersion estimates are based on use of the Gaussian dispersion equation and plume rise is predicted using the methodology of Briggs (1969). The results are modified by time correction factors developed by TVA to account for the variability of the plume for different averaging periods (Montgomery, 1975). However, concentrations for varying terrain heights are not accounted for in the model. Maximum concentrations were determined by a parametric analysis of various combinations of atmospheric stabilities and wind speeds using the following equation:

$$\chi = \frac{Q}{\pi \sigma_y \sigma_z \bar{u}} \quad \text{EXP} \left[-\frac{1}{2} \left(\frac{h_e}{\sigma_z} \right)^2 \right]$$

where

χ = concentration
Q = source term emission rate
$\bar{u}$ = mean wind speed for stability class i, m/sec
σ_z = vertical dispersion parameter for stability class i, m
σ_y = horizontal dispersion parameter for stability class i, m
h_e = effective stack height, m

The results of the short term concentration calculations are presented in Table 6-5-30. Compared to the applicable air quality standards and considering the low background levels of CO in the site region, the results indicate conformance to applicable air quality standards at and beyond 3 km from the source.

Table 6-5-30

PREDICTED MAXIMUM CONCENTRATIONS FOR CO
ASSOCIATED WITH MINE VENTILATION EMISSIONS

Downwind Distance (km)	CO ($\mu g/m^3$) 1-hour	CO ($\mu g/m^3$) 8-hour	NO_x ($\mu g/m^3$) Annual
1.5	59,000	20,000	1.1
3.0	42,000	14,000	1.6
6.0	25,000	8,700	9.7
8.0	21,000	7,500	6.8
10.0	21,000	7,500	4.9

Long term concentrations were computed by the computer program CRSTER developed by EPA (Novak, 1976). The methodology used in CRS has been discussed in Section 5.7.A.4.a. The results of annual calculations are presented in Table 6-5-30 for the maximum affected sectors. Compared to the applicable air quality standards and considering the low background levels in the site region, the results presented in Table 6-5-30 indicate compliance to air quality standards for NO_x.

B. Salt Drift From Cooling Tower - Wet cooling towers contact cooling water with an air stream and cool the circulating water by evaporation. The air stream entrains a small percentage of the circulating water as droplets small enough to be transported some distance from the cooling tower. Salt drift simulation allows the calculation of the rate of deposition of dissolved solids in the entrained droplets so that their effects on biological systems can be assessed. The environmental impact assessment of salt drift deposition from cooling towers is described in Section 7, Chapter 4.

The mechanical draft wet cooling tower for the RBOSP is located about 230 m north of the surface retorts. The tower is composed of 5 individual cells with a fan mounted on top of each cell. The fan draws ambient air through

the tower cell where it contacts the condenser cooling water. The relative humidity of the exit air is assumed to be 100%, independent of ambient meteorological conditions. In the operation of the cooling water system, dissolved solids tend to be concentrated within the system through evaporation of water. The concentration of solids, including corrosive ions, can be maintained at a constant level by discharge (blowdown) of a portion of the total recirculating water. The tower is designed to operate a 6 cycles of concentration; at an intake concentration of 1550 ppm for dissolved solids, this yields 9300 ppm dissolved solids for the condenser cooling water.

The analytical model used to predict ground deposition of dissolved solids in the drift release by the cooling tower is the NUS FOG computer code. This is a one-dimensional analytical model capable of simulating the operation of mechanical draft wet cooling towers. Plume rise equations (Briggs, 1969) are used for the rise of the exit plume from the cooling tower. Atmospheric dispersion is determined by the turbulence produced by the cooling system emissions and by the stability class. During the initial rise of the plume (the bent-over stage), the depth of the plume is equal to the rise of the plume above the source height (Briggs, 1969). After the plume levels off at some equilibrium height, the size (and therefore the dispersion) of the plume is affected primarily by the atmospheric stability class. The stability class is obtained from site measurements of the temperature lapse rate using the Nuclear Regulatory Commission's criteria for stability classes (USAEC, 1972). Plume rise is controlled in part by a computed buoyancy term, which is a function of the volumetric flow rate of the effluent air through the cooling tower together with the density difference of this air compared to ambient conditions. Buoyancy effects from individual cells in the tower are assumed to be enhanced if the wind is blowing parallel to the length of the tower. If the wind is blowing normal to the tower axis, the buoyancy is computed from only one mechanical draft tower cell. For intermediate wind directions, a sine function is used in the calculation of the buoyancy effect.

Under high wind conditions a cooling tower structure acts to produce a zone of low pressure immediately to the lee of the tower. At a certain critical wind speed this induced pressure differential will draw the plume towards the ground lee of the tower. This condition of structural downwash intensifies close in ground level effects downwind of the tower. Critical wind speed is a function of the buoyancy of the effluent; the expression for the critical wind speed for the mechanical draft tower is obtained from Briggs (Briggs, 1969).

As the plume extends downwind from the cooling tower it is assumed to propagate rectilinearly; that is, the meandering effect of the ambient horizontal wind shear is neglected. This wind shear has the effect of further diluting the effluent plume. The assumption of rectilinear propagation leads to conservatism in the calculation of the ground level centerline effects and of the length of the visible plume.

As the air passes through an evaporative cooling tower, small water droplets become entrained in the airflow and are carried upward in the effluent plume as drift droplets. The salt (or dissolved solids) deposition analysis involves the calculation of the trajectories of these drift droplets of different sizes as well as the growth and evaporation of the droplets due to condensation and evaporative processes. In this model it is assumed that at any point in the plume the excess water vapor, the temperature excess, the vertical motion, and the drift droplets (independent of size) follow a Gaussian distribution normal to the plume axis. The distribution vertically through the plume is distorted from a true Gaussian form, but this distortion is reduced as the plume becomes more horizontal. In the model, a vertical Gaussian distribution is used as a simplifying assumption. The plume is assumed to extend to 2 standard deviations ($2\sigma_y$ and $2\sigma_z$) away from the plume axis. The release of the entrained drift droplets at any point within the plume depends on the relative magnitudes of the terminal fall velocity of the droplets and the vertical motion of the plume air. The rate of change of droplet size is a function of relative humidity of the ambient air, the fall velocity of the droplet, the salt concentration in the drop and the curvature of the surface of the drop. The

total rate of salt released by a system (mass/time) is a function of the volume of water passing through the cooling system, the drift rate (expressed as a percentage of the water flow) and the concentration of salt within the cooling water.

This analysis was based on onsite meteorological data at Site 1 for a 1 yr. period (9/1/74-8/31/76). The total rate of dissolved solids released by tower as drift is 6.33 g/sec.

The dispersion pattern of airborne effluents from a mechanical draft tower depends in part upon the orientation of the tower with respect to the wind direction. As noted above, a wind blowing parallel to the length of the tower tends to merge the effluent from each cell, thereby causing a greater plume buoyancy and subsequent rise. Generally, the greater the plume rise, the smaller the ground level effects. Accordingly, the tower was oriented in a WSW-ENE direction in order to obtain conservative results. This is the most frequent wind direction based upon wind direction data obtained at Site 1.

Ground deposition of dissolved solids within 2.25 km of the tower is shown in Figure 6-5-29, while Figure 6-5-30 shows predicted depositions within 250 m from the tower. The maximum rate of deposition is located approximately 90 m north-northeast of the cooling tower where the predicted annual deposition rate is approximately 500 g/m^2. The predicted ground deposition of dissolved solids beyond 1.65 km is calculated to be less than 1 g/m^2 year.

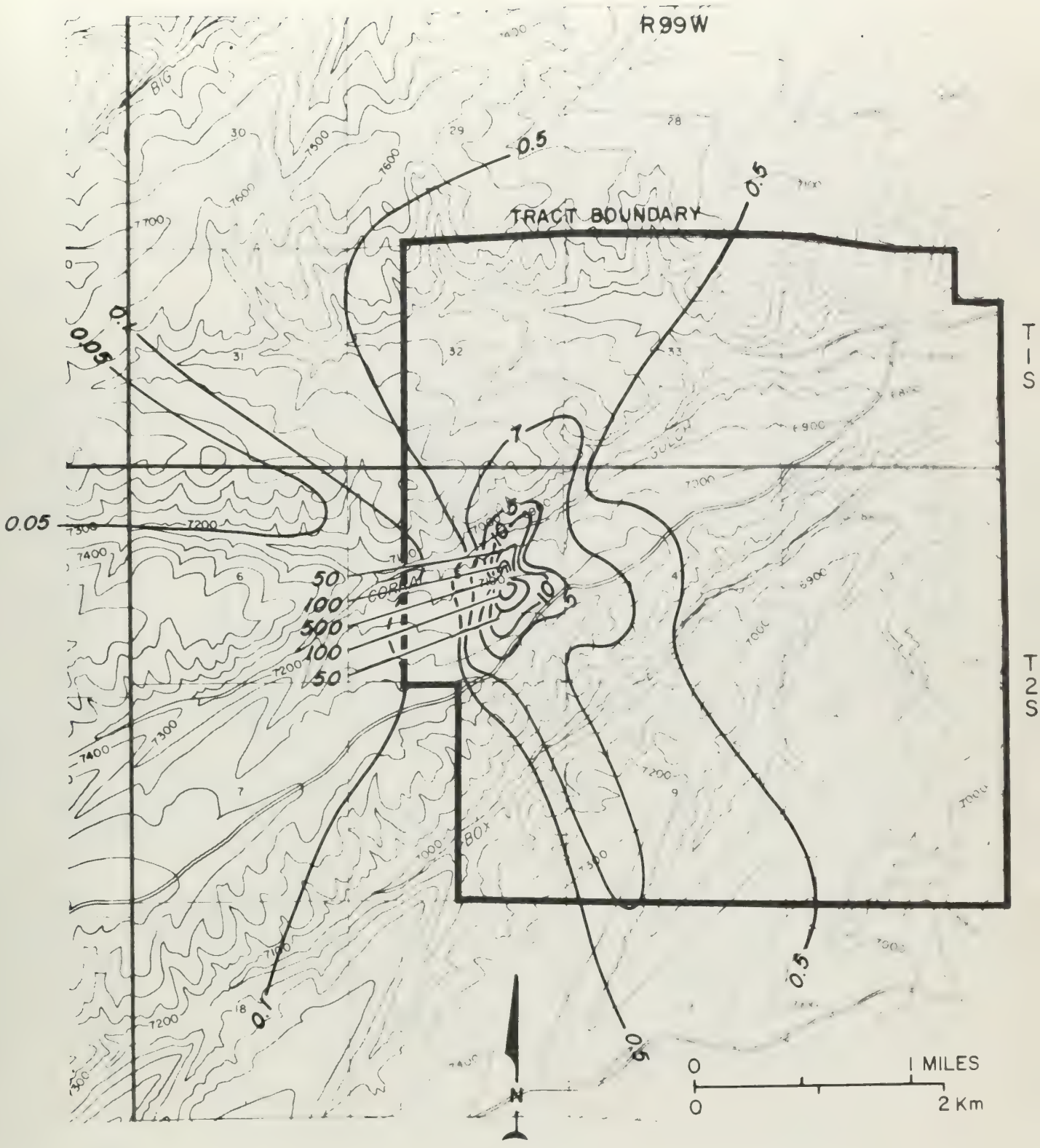


Figure 6-5-29

DEPOSITION OF DISSOLVED SOLIDS WITHIN 2.25 KILOMETERS FROM THE MECHANICAL DRAFT TOWER, gm/m^2 - YEAR

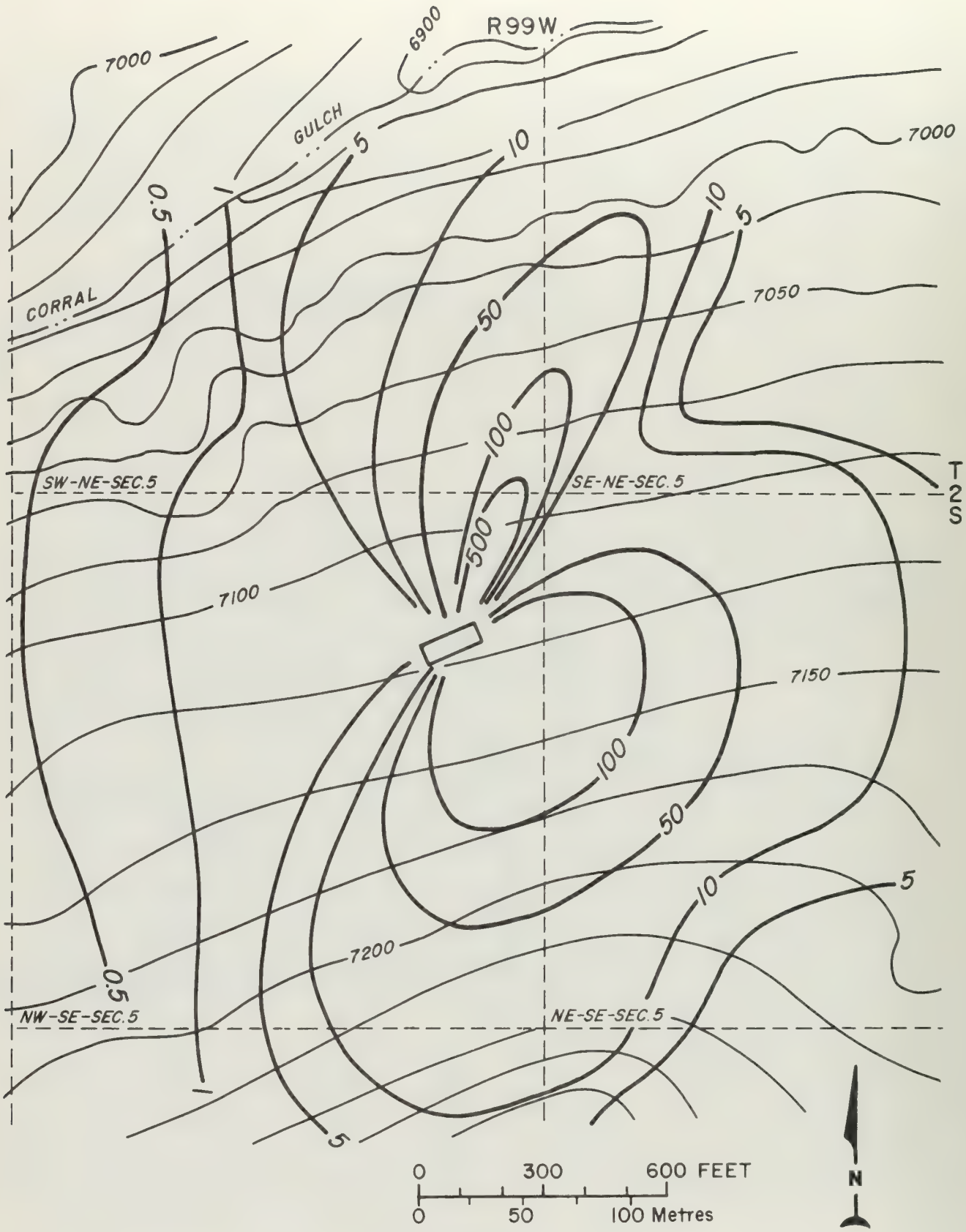


Figure 6-5-30

DEPOSITION OF DISSOLVED SOLIDS WITHIN 250 METERS,

FROM THE MECHANICAL DRAFT TOWER, gm/m^2 - YEAR

5.8 APPLICABLE REGULATIONS

The development of the oil shale resource will involve many individuals, organizations, communities and County, State and Federal governments. The orderly development of this resource calls for compliance with many public health and air quality regulations. The most pertinent of these regulations and agencies are listed below.

A. Tract C-a Shale Lease - Environmental Stipulations and References.

B. National Environmental Policy Act of 1969 and the Environmental Protection Agency, Public Law 91-190, January 1, 1970.

- The Federal Clean Air Act:
  42 U.S. Code 1857-19751, Public Law 91-604, 84 Stat. 1676.
- National Ambient Air Quality Standards:
  Federal Register, Vol. 36, No. 67, April 6, 1971.
- Standards of Performance for New Stationary Sources:
  Federal Register, Vol. 36, No. 247, December 23, 1971.
- Prevention of Significant Air Quality Deterioration:
  Federal Register, Vol. 39, No. 235, December 5, 1974.

C. Occupational Safety and Health Act of 1970, - Public Law 91-596, S.2193, December 23, 1970.

- o OSHA, Construction and Health Regulations:
  Federal Register, June 27, 1974, Part II.
- o OSHA, Occupational Safety and Health Standards:
  Federal Register, June 27, 1974, Part II.
- o MESA, Memorandum of Understanding Between MESA and OSHA:
  Federal Register, July 26, 1974.

D. Mining Enforcement and Safety Administration (MESA)

- o MESA, Mine Standards:
  United States Department of the Interior, March 1974.
- o Federal Metal and Nonmentallic Mine Safety Act of 1966:
  Public Law 89-577, H.R. 8989, September 16, 1961
- o Sand, Gravel and Crushed Stone Operations:
  30 CFR Part 56
- o Underground Mines:
  30 CFR Part 57.

E. State of Colorado Air Pollution Control Act of 1970, Chapter 66, Article 31.

- o Regulation No. 1 - Emission Control Regulations for Particulates, Smokes and Sulfur Oxides for the State of Colorado.
- o Regulation No. 2 - Odor Emission Regulations.
- o Regulation No. 3 - Regulation Governing Air Contaminant Emission Notice, Emission Permit and Fees for Direct Sources.
- o Regulation No. 6 - Standards of Performance for New Stationary Sources.
- o Regulation No. 7 - Regulation to Control the Emissions of Hydrocarbon Vapors.
- o Regulation No. 9 - Regulation to Control Emissions to Chemical Substances and Physical Agents.
- o Ambient Air Standards for Metropolitan Denver, Air Quality Control Areas and the State of Colorado.

F. Colorado Mining Laws with Safety and Health Regulations, Bulletin 20, Colorado Bureau of Mines, Denver, Colorado, January 1, 1971.

G. Colorado Department of Labor and Colorado Occupational Safety and Health (COSH).

5.9 DEFINITIONS

The following terms have been used in the text or in various regulations and are defined as used here to assist the reader in gaining a clear understanding of the Air Quality Control Plan.

Air Contaminant - Any fume, smoke, particulate matter, vapor, gas or any combination thereof, but not including water vapor or steam condensate.

Air Contamination Source - Any source whatsoever at, from, or by reason of which there is emitted or discharged into the atmosphere any air contaminant.

Air Pollution - Any concentration of one or more air contaminants in the outdoor atmosphere that has caused, is causing, or if unabated may cause injury to human, plant or animal life, or injury to property, or which unreasonably interferes with the comfortable enjoyment of life or property or with the conduct of business.

Ambient Air - The surrounding outside air.

Atmosphere - The air that envelops or surrounds the earth. For the purpose of this regulation, emissions of air contaminants from a building or structure not specifically designed to control air pollution originating from an air contamination source or sources within such building or structure shall constitute an emission to the atmosphere.

Bagfilter - A filtering apparatus with porous cloth or felt bags through which dust-laden gases are sent, leaving the dust on the surfaces of the bags.

Baghouses - The large chamber or room and associated equipment for holding and operating bagfilters used to filter dust-laden air or gas streams.

Emission - The discharge or release into the atmosphere of one or more air contaminants.

Emission Control Regulation - Any standard promulgated by regulation which is applicable to all air contamination sources within a specified area and which prohibits or establishes permissible limits for specific types of emissions in such area, and also any regulation which by its terms is applicable to a specified type of facility, process, or activity for the purpose of controlling the extent, degree or nature of contamination emitted from such type of facility, process, or activity, and also any regulation adopted for the purpose of preventing or minimizing emission of any air contaminant in potentially dangerous quantities.

Fuel Burning Equipment - Any furnace, boiler apparatus, stack or appurtenances thereto used in the process of burning fuel for the primary purpose of producing heat or power by indirect heat transfer.

Fugitive Dust - Solid airborne particulate matter emitted from any source other than an opening which channels the flow of air contaminants and then exhausts the contaminants directly into the atmosphere. Fugitive dust also includes solid particles released into the atmosphere by natural forces or by mechanical processes such as crushing, grinding, milling, drilling, demolishing, shoveling, conveying, covering, bagging, sweeping, etc.

GMT - Greenwich Mean Time.

LST - Local Solar Time.

MSL - Mean Sea Level.

National Primary Standard - National Primary Ambient Air Quality Standards define levels of air quality which the EPA Administrator judges are necessary, with an adequate margin of safety, to protect the public health.

National Secondary Standard - National Secondary Ambient Air Quality Standards define levels of air quality which the EPA Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

Opacity - The degree to which an air contaminant emission obscures the view of an observer, expressed in percentage of the obscuration, or in the degree (percent) to which transmittance of light is reduced by an air contaminant emission.

Open Burning - The burning of any material in the open or in a receptacle other than a furnance, incinerator, or other equipment connected to a stack or chimney.

Opening - Any single chimney, conduit, duct, smokestack, flue or other contrivance from which air contaminants are exhausted into the atmosphere.

Palliative - A solution or material applied to roads or land surfaces to prevent the formation of dust due to traffic or other use.

Petroleum Distillate - Any finished and intermediate products which are manufactured in crude petroleum processing and finishing operations having a vapor pressure of 1.5 psia or greater, including gasoline manufactured from any source or by using any process.

Process or Process Equipment - Any action, operation, or treatment, involving chemical, industrial, or manufacturing factors, such as furnaces, by-product coke plants, heating and reheating furnaces, kilns, dryers, roasters, and equipment used in connection therewith, and all other methods or forms of manufacturing or processing that may emit air contamination.

Process Unit - Any single process or process equipment.

Process Weight - The total weight of all materials introduced into a source operation, which source causes any discharge of air contaminants into the atmosphere. Solid fuels introduced into any specific source will be considered as part of the process weight, but liquid and gaseous fuels and combustion air will not.

Process Weight Rate - A rate established as follows:

- For continuous source operations, the total process weight for the entire period of continuous operation or for a typical portion thereof, or;
- For cyclical or batch unit operations, or unit processes, the total process weight for a period that covers a complete operation or an integral number of cycles, divided by the hours of actual process operation during such a period, or;
- For operations not specified above, determine the process weight that results in a minimum value of allowable emissions.

Retardant - A material that inhibits the movement of soil particles and tends to bind them together in a crust-like formation. Examples are polymers, latex, or other cohesive binder.

Smoke - Small gas borne particles resulting from incomplete combustion, consisting predominantly, but not exclusively, of carbon and other combustible material.

Stack or Chimney - Any vertical flue, conduit, or duct arranged to conduct an effluent to the open air.

Standard Conditions - A gas temperature of 68 degrees Fahrenheit and a gas pressure of 29.92 inches of mercury.

Stationary Source - Any building, structure, facility, or installation which emits or may emit any air pollutant.

Suppression - The means of controlling or allaying dust by the use of water or wetting agents.

Surfactant - Is an acronym meaning surface-active-agent which is a soluble compound that reduces the surface tension of liquids, or reduces interfacial tension between two liquids or a liquid and a solid such as a detergent, soap solution, or wetting agent.

Upset Conditions - An unpredictable equipment failure or other malfunction which results in the violation of emission control regulation, and which is not due to improper or careless operation.

CHAPTER 6

WATER QUALITY CONTROL

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER 6
WATER QUALITY CONTROL

The water quality control plan to be employed in developing Tract C-a is an adaptation of the American Petroleum Institute's zero discharge water concept. A portion of the water produced is planned to be consumptively used either through evaporation to the atmosphere, through processing needs, through dust control needs, or by absorption in the processed shale disposal pile. The remaining groundwater produced from dewatering wells and mine seepage is planned to be reinjected into the groundwater aquifers.

The water control system will be designed to control surface runoff water, mine dewatering and the processing of waste waters. Surface water originating outside the Tract C-a project area will be diverted around the mine site, processing facilitity and disposal areas. Surface water originating within the project area will be controlled by a series of collection ditches and retention dams and will be recycled to the process water system, used for dust control or evaporated.

A majority of the groundwater from the mine dewatering wells will be pumped and reinjected into the groundwater aquifers off the tract. Some of the groundwater will be treated to provide potable water required at the mine facility, disposal area maintenance shop and shale oil process plant.

Part of the mine seepage water will be used for dust control. The remainder will be treated and used for process needs and fire protection or reinjected with the excess water from the dewatering wells.

MIS retort water will be evaporated in a thermal oxidizer during the Modular Development Phase (MDP). It will be treated before it is used

for process needs during the Commercial Phase. See Section 3, Chapter 2.1.C and Chapter 3.1.A.

Surplus waste water and blowdown water will be disposed of in an evaporation field and by sprinkling on the processed shale and development ore disposal areas.

Mine dewatering is expected to provide more than enough water for the projected demand. RBOSP has conducted an active program of securing rights to the ground and surface water supplies needed for Tract C-a development within the prior appropriation doctrine under which Colorado administers the use of its water.

Most of the groundwater existing in the vicinity of Tract C-a is part of a basin-wide aquifer system, wherein the water is in a state of transient storage and moving slowly towards discharge into surface streams in the area. Because most of the groundwater that is removed to allow an underground mining and MIS retorting operation will be reinjected, the overall effect on the aquifer system will be minimized.

Retention ponds will be lined with impermeable material as will the processed shale pile runoff collection ditches. Most other ponds and ditches probably will not be lined unless further investigation indicates that it will be necessary.

Dams creating ponds or reservoirs will be constructed in accordance with standards and specifications approved by the Colorado State Engineer and the AOSS. Materials native to the region will be used wherever feasible. Cores of dams will be constructed of impervious materials.

Further details of the Water Management Plan and facilities developed to implement water quality control can be found in Section 5, Chapter 5.

6.1 ZERO DISCHARGE WATER HANDLING

The zero discharge technique was developed by the American Petroleum Institute to help U.S. refineries reduce their water consumption. An added benefit of the system is that energy use is also reduced and adverse effects on ground and surface waters are minimized.

Figure 6-6-1 is a schematic comparison of typical conventional and typical zero discharge water handling systems. This figure shows a typical system and is not the flow schematic for the Rio Blanco Oil Shale Project. The zero discharge system is represented by the dashed line and changes from the conventional system by the small dotted line; solid lines are common to both systems. Zero discharge differs from conventional water handling in several respects. For example, rainfall runoff is collected throughout the plant area with a conventional storm sewer system, but instead of sending the water directly to the API separator and then discharging it to a natural water course as in conventional system, the water is collected, stored, then pumped to cooling towers. Another difference is that more cycles of concentration are used in cooling towers to minimize blowdown.

The zero discharge water concept is easily adaptable to the Rio Blanco Oil Shale Project because waste treating, concentration drying and solid waste disposal, as shown on Figure 6-6-1, will not be required. Instead, water from the API separator will be used for process needs such as cooling tower makeup and moisturizing processed shale. Some of this water will also be used for dust control.

6.2 MODULAR DEVELOPMENT PHASE

Precise amounts of water flowing throughout the RBOSP system are unpredictable with currently available information; however, the water usage

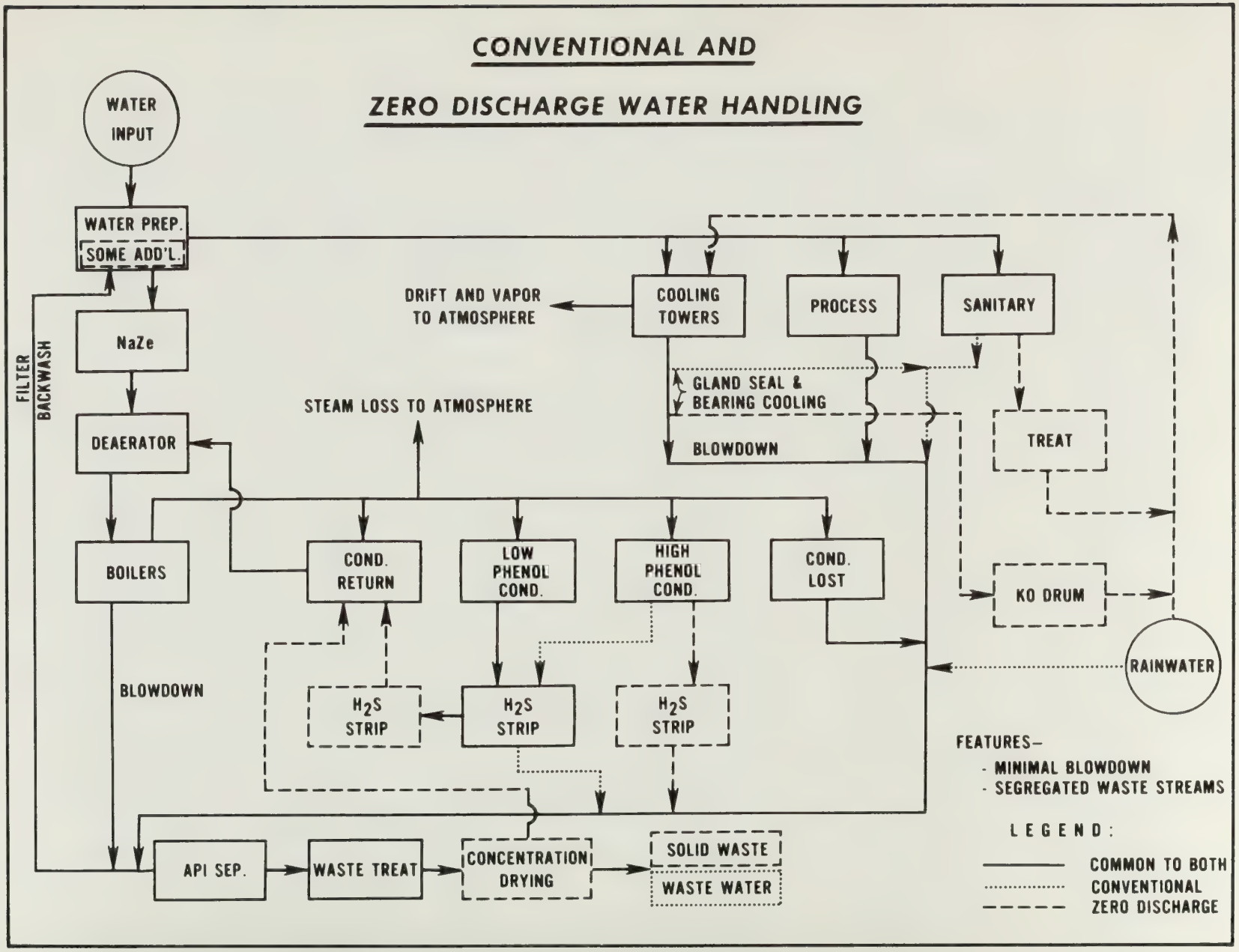


FIGURE 6-6-1

TYPICAL CONVENTIONAL and ZERO DISCHARGE WATER HANDLING

under average MDP operating conditions is estimated to be as shown in Table 6-6-1.

Table 6-6-1

WATER USAGE
MODULAR DEVELOPMENT PHASE

Source	Use - GPM		
	Potable	Process	Dust Control
Upper Aquifer	35	-	-
Lower Aquifer	-	-	-
Mine Seepage	-	430	180
MIS Retort	-	250	-
Surface Drainage	-	30	40
Total - GPM	35	710	220

Groundwater usage, from upper and lower aquifers and mine seepage, amounted to about 645 gpm or 1000 AFY.

A. Water Flow - The overall water flow for the MDP is illustrated on Figure 6-6-2. The major portion of the water from mine dewatering wells and treated mine seepage water will be reinjected. The MIS retort water will be evaporated in the thermal oxidizer. Surface runoff and sewage effluent will be recycled for use as process water and for dust control.

B. Dewatering and Reinjection - During the MDP, several dewatering sites will be located in the vicinity of the mine shafts and mine service area. Each site will contain two wells: one for the upper aquifer and the other for the lower aquifer. Dewatering wells will be abandoned and added as operations expand into the Commercial Phase. The mine seepage water that is not used consumptively will be treated by filtration and reinjected along with the water from the dewatering wells.

Water will be collected from the dewatering wells and distributed to the reinjection wells by a piping system. The reinjection of water will

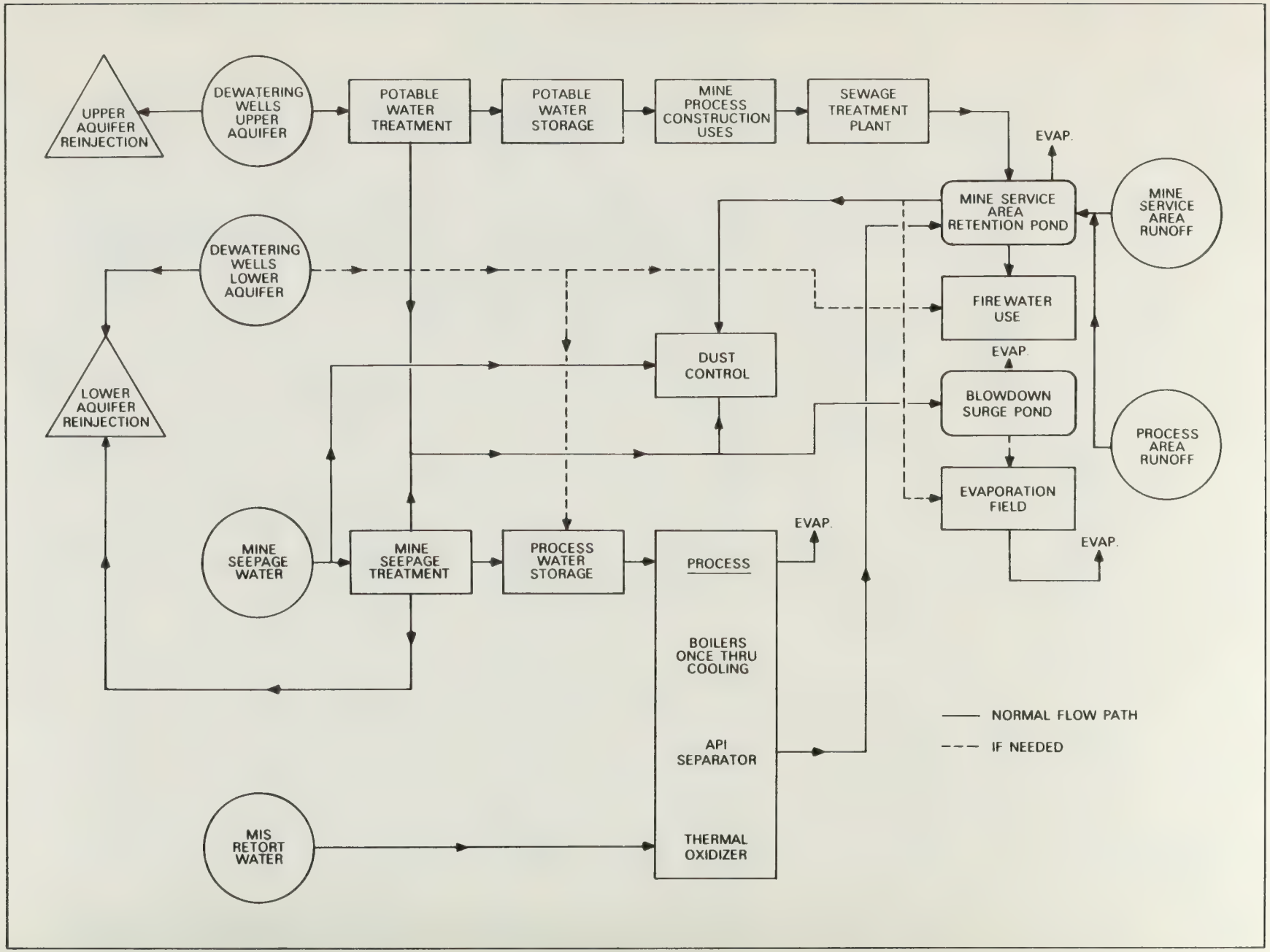


FIGURE 6-6-2

WATER FLOW - MODULAR DEVELOPMENT PHASE

help maintain the natural flow of springs and minimize the effect on wells. The reinjection wells will be located, based on computer modeling, to enhance this augmentation effort.

The reinjection technique will allow the project to comply with the zero discharge concept for surface waters and will reduce major disturbances of the groundwater aquifers.

C. Evaporation and Dust Control - Sources of evaporation during the MDP are the thermal oxidizer, evaporation field and retention ponds. The dust control water will be supplied from the mine service area retention pond and from the blowdown surge pond. The relatively small amounts of water used for construction and haul road dust control will evaporate.

D. Potable Water - The supply for potable water will be drawn from dewatering wells which tap the upper aquifer. The potable water system will include a storage tank and reverse-osmosis water treatment system which will provide water of an acceptable quality. The size of the system is based upon the maximum usage by the people that will be employed on the tract at any one time.

E. Processing Facility - Disposition of process water is described in Section 3, Chapter 2.1.

F. Surface Runoff, Diversion and Retention - The surface runoff is divided into two categories. One is runoff water originating outside the plant facilities. The other is water originating inside of the plant facilities and construction sites. Each of these waters will have to be handled separately in order to comply with the zero discharge concept.

Surface runoff originating outside the plant site, mine service facility and disposal areas will be allowed to continue its natural flow into the Corral Gulch and Box Elder Gulch drainage system. The mine service area

retention pond will be constructed to collect the runoff from the mine service area facilities. This pond will be located at the low end of the mine service area. The runoff water from the mine service area will be recycled as process and dust control water. Any excess will be disposed of by evaporation from the retention ponds or in an evaporation field located near the mine service area.

Runoff water from the development ore stockpiles, run-of-mine (ROM) and crushed, will be collected in a series of ditches where sediment will be permitted to settle. The water will normally evaporate in the ditches. In the event of excessive runoff, the settled water will be discharged to natural drainages.

The design basis for surface runoff, diversion and retention facilities will be as follows:

- Ditches will be sized for the peak flow expected from a short duration, 100-year storm.
- Collection ponds and reservoirs not in drainages will be sized to hold the runoff from a 100-year storm of six hours duration. Consideration will be taken for differences in runoff for developed areas (paving, etc.) and undistrubed areas.
- Diversion ditches and impoundments in drainages (such as Corral Gulch) will be designed to withstand the 100-year flood in the drainage.
- Containment structures for storage tanks will be designed to contain maximum trapped precipitation and runoff in addition to 150% of the storage tank volumes.
- Calculations for predicting peak flows and storage requirements will be based on methods used by the Soil Conservation Service, U. S. Department of Agriculture, or other appropriate methods.
- Plans and procedures will consider the effects of extremely heavy rainfall and flash floods.

G. Fire Protection Water - Adequate line sizes and storage capacity will be provided to comply with the fire codes. A storage capacity of 500,000 gallons will be reserved for fire protection use in the mine service area retention pond.

One 750 gpm diesel-driven pump and one 750 gpm electric motor-driven pump will provide fire water flow and pressure. Additional water supply will be available from the dewatering system pipeline.

H. Sanitary Sewage Treatment Facilities - A single commercial sewage treatment plant will be constructed in the mine service area to handle the sewage from the mine, the processing units and the construction operation during the MDP. Effluent from the sewage treatment plant will be stored in the mine service area retention pond and used for fire protection, process water and construction and haul road dust control.

6.3 COMMERCIAL PHASE

The estimated water usage during the Commercial Phase is shown in Table 6-6-2.

Table 6-6-2

WATER USAGE
COMMERCIAL PHASE

Source	Use - GPM		
	Potable	Process	Dust Control
Upper Aquifer	60	-	-
Lower Aquifer	-	-	-
Mine Seepage	-	550	750
MIS Retort	-	1400	-
Surface Drainage	-	270	500
Total GPM	60	2220	1250

Groundwater usage, from upper and lower aquifers and mine seepage, amounts to about 1360 gpm or 2200 AFY.

A. Water Flow - The water flow for the Commercial Phase is shown on Figure 6-6-3. Less water will be reinjected and more will be consumed during the Commercial Phase than in the MDP.

Mine seepage water will be treated and combined with water from the mine dewatering wells for reinjection. The MIS retort water will be steam stripped; part will be distilled for use in the process and the remainder will be used for processed shale moisturizing. Rinky Dink Reservoir will store contaminated runoff and leachate which will be used for dust control at the disposal area. Surface runoff and sewage effluent from the plant and mine service areas will be recycled for use as process water or dust control.

B. Dewatering and Reinjection - As now planned, the MDP dewatering well system will be expanded for the Commercial Phase when the dewatering well system will reach a maximum of 19 dewatering sites. Each site will contain two wells: one for the upper aquifer and one for the lower aquifer. Maximum dewatering with wells during this phase is projected to be about 17 cubic feet per second (cfs). Mine seepage water up to approximately 8 cfs, will be pumped to the surface during the Commercial Phase of the project (see Section 2, Chapter 6, Mine Design). This water will be used for dust control and sprinkling. The excess will be treated for use in the process and for reinjection along with the excess water from the dewatering wells. The reinjection techniques for the Commercial Phase are identical to those described for the MDP.

C. Evaporation and Dust Control - Sources of evaporation are cooling towers, retort scrubbers, retention ponds, storage reservoirs and the evaporation field. Most of the water used for dust control on the surface of the processed shale disposal pile will either evaporate or be absorbed by the processed shale. The pile itself will be constructed to be almost impervious which will prevent saturation by precipitation and the associated migration of leachate through the pile. The water used for dust control on roads and other areas in the project complex will evaporate.

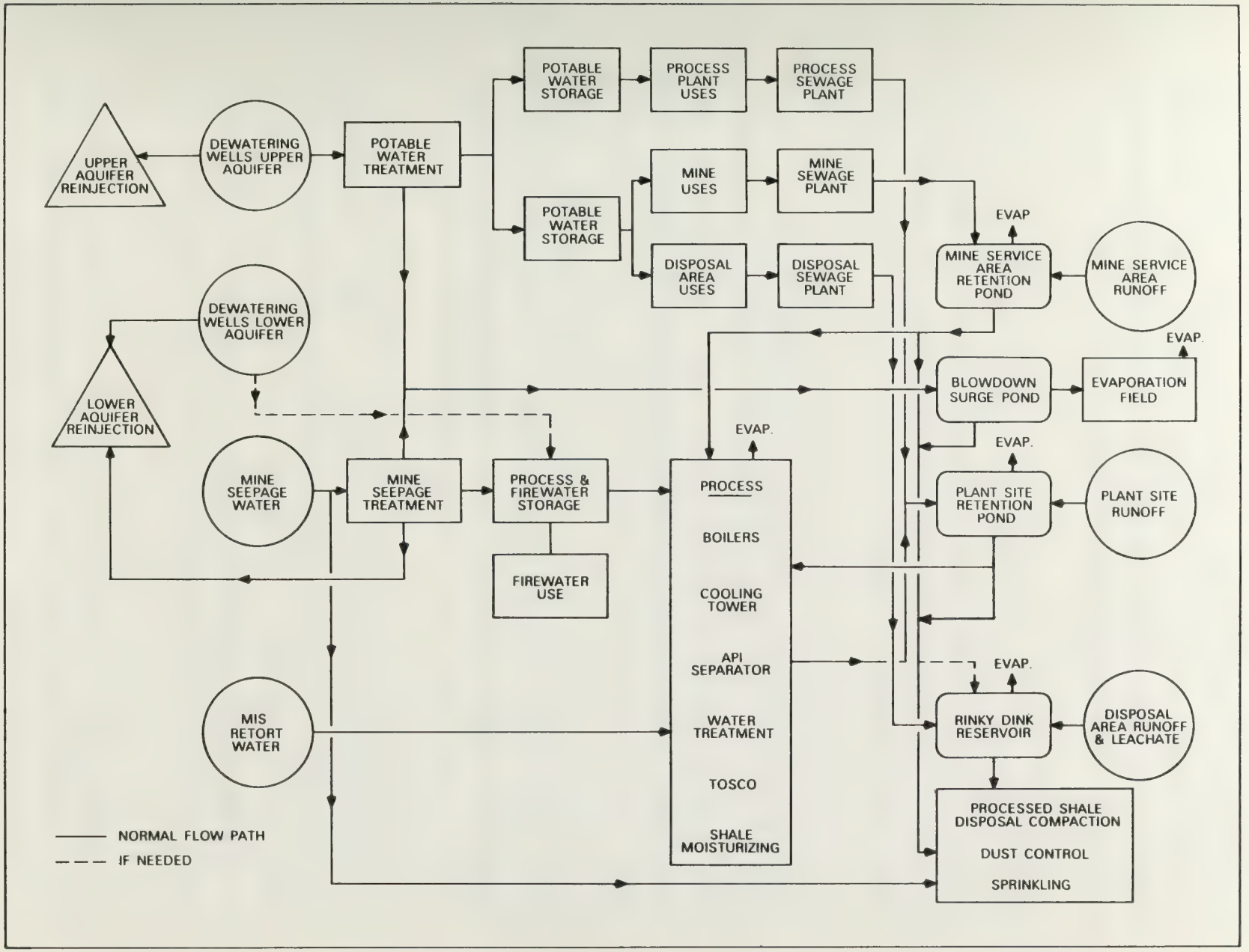


FIGURE 6-6-3

WATER FLOW - COMMERCIAL PHASE

D. Processed Shale Disposal Pile - The sources of contaminated water from the disposal pile are surface runoff and, possibly, processed shale leachate. Runoff originating outside the disposal area will be diverted around the area to a drainage downstream of the pile. This system will be continually modified as the pile grows.

Surface runoff from the pile will be collected by a series of lined ditches around the perimeter of the pile, then conveyed to Rinky Dink Reservoir at the northeast edge of the pile. The water in Rinky Dink Reservoir will either evaporate or be returned to the pile for dust control and/or compaction needs.

Construction of the disposal pile is described in Section 4. It will be constructed to preclude or minimize the discharge of leachate by surrounding the main body of processed shale on all sides with an impermeable layer of highly compacted processed shale; however, in the event that some leachate is discharged, it too will be conveyed to Rinky Dink Reservoid.

During the months when extremely heavy rainfalls might be expected, extra measures will be taken to prevent erosion of the disposal pile. These measures could include such things as dishing the top surface to retain or control runoff and covering exposed slopes with rock.

E. Potable Water - The reverse-osmosis water treatment system installed in the MDP will also serve the Commercial Phase. A storage tank and distribution lines will be added for the Commercial Phase.

F. Processing Facilities - Water for the processing facility is supplied from a storage tank and will be distributed to the points of use.

Waste water streams in the processing facility are: blowdown from the cooling tower and the steam boiler, water collected from retorting and oil recovery operations which has been stripped with steam, and surface

runoff. Stripped water will be sent to an evaporator where a portion of the water will be distilled. Residual water from the evaporator, cooling tower blowdown and boiler blowdown are all used to moisturize processed shale from aboveground retorting operations. Distilled water from the evaporator will be reused for steam generation.

Surface water runoff from the processing plants will be first sent to an API separator, and then to the plant site retention pond. Clear water from the retention pond will be used to moisturize processed shale. The water control plan for the Commercial Phase processing facility thus provides zero discharge of water from the processing facility to the environment.

Additional information for the processing facilities during the Commercial Phase is described in Section 3, Chapter 3.

G. Surface Runoff, Diversion and Retention - Surface runoff will be controlled throughout the project area. Diversions will be provided around the mine, processing facility, and disposal piles. Surface water originating outside operating areas will be diverted around the facilities and returned to an existing watercourse downstream. Surface runoff originating within the operating areas will be controlled and included in the zero discharge system.

Surface runoff originating off the tract and outside the plant site, mine service facility and disposal areas will be allowed to continue its natural flow into the Corral Gulch and Box Elder Gulch drainage systems. A relatively modest diversion system will be required to convey water from the Rinky Dink Gulch around the processed shale disposal area and into Box Elder Gulch. A plant site retention pond will be constructed in Corral Gulch to collect the runoff from the plant site. The mine service facility retention pond constructed in the Modular Development Phase will collect the mine service area runoff. The evaporation field will also be used for disposal of excess water. The runoff water will

be recycled the process facility or used for dust control. Excess water will be pumped to Rinky Dink Reservoir or disposed of by evaporattion.

The runoff water from the processed shale disposal area will be caught in lined diversion ditches and run to Rinky Dink Reservoir where it will be retained for use in compaction and dust control requirements on the disposal site.

The design basis for surface runoff, diversion and retention facilities will be the same as shown in 6.2F of this chapter.

H. Fire Protection Water - Fire protection water will be supplied from the process and fire protection water storage tank. This tank will have 5,000,000 gallons reserved for fire protection purposes. The tank is located at such an elevation that adequate pressure will be available by gravity for all locations except for very tall structures. Two 1000 gpm electric motor-driven booster pumps will be provided in the vicinity of the TOSCO processing area to provide protection for tall structures. Additional water will also be available from the dewatering well system.

I. Sanitary Sewage Treatment Facilities - The commercial sewage treatment plant installed for the MDP will be adequate to serve the mine service area. During the Commercial Phase, two additional treatment plants will be constructed. One will treat the sewage from the process facility and be located in the plant area. The effluent from this sewage treatment plant will be contained in the plant site retention pond and will be recycled to the processing facility. The other sewage treatment plant will be located at the truck shop near the processed shale disposal area. The effluent from this plant will flow to Rinky Dink Reservoir.

6.4 SUMMARY

In effect, RBOSP will control water quality during Tract C-a development by controlling water flows and not permitting low-quality water to be

discharged to area surface streams or to groundwater aquifers. To ensure that the system is effective, a water monitoring program will be conducted as described in Section 8, Chapters 5 and 6.

In addition to the water control system described in this chapter, RBOSP will implement other control systems that will also serve to prevent water pollution. The control of oil and other hazardous materials, including the spill contingency plan for the product pipeline from Tract C-a to Rangely, is described in Chapter 7 of this section.

CHAPTER 7

OIL & HAZARDOUS MATERIAL CONTROL

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER 7

OIL AND HAZARDOUS MATERIAL CONTROL

The Oil and Hazardous Material Control Plan has been formulated recognizing that the best control plan is prevention of spills through proper design of storage, handling and transporting facilities. However, a spill contingency plan will be implemented during all phases of the project establishing procedures to be followed to minimize damages in the event of accidental spills.

This spill contingency plan includes procedures for notification, containment, repair and cleanup of spills. The primary objective is to minimize, as far as practicable, any damage from an oil spill to persons, property, flora and fauna.

7.1 APPLICABLE REGULATIONS

Facility design and contingency planning have been developed in conformance with the applicable regulations, codes and standards. Principal regulations follow:

- U.S. Department of the Interior, Oil Shale Lease Tract C-a, February 5, 1974
- Title 49, Chapter 1, Part 195, Transportation of Liquids by Pipeline, Department of Transportation
- Title 40, Chapter 1, Part 165, Federal Register (FR) 39, No. 85, May 1, Regulations for the Acceptance of Certain Pesticides and Recommended Procedures for the Disposal and Storage of Pesticides and Pesticide Containers.
- Title 40, Chapter 1, Part 112, FR 38, No. 237, December 11, 1973, Oil Pollution Prevention (Nontransportation-Related Onshore and Offshore Facilities).

- Title 40, Chapter V, Part 1510, FR Vol. 40, No. 28, February 10, 1975, National Oil and Hazardous Substances Pollution Contingency Plan.
- PL 92-500, Federal Water Pollution Control Act Amendments of 1972.
- Colorado Revised Statutes (1973) 25-8-601 - Requires Notification of Spillage to Colorado Department of Health.
- Colorado Senate Bill No. 390, Water Quality Control.
- Colorado Health Department - Procedures and Directory for Reporting Spills of Oil and Hazardous Materials.

7.2 STORAGE AND HANDLING

A. Storage - The facilities for storage of large quantities of product oil, other hydrocarbon products; diesel fuel, by-product sulfur and any other chemicals will be designed to minimize the possibility of spillage. The layout and construction of the tanks, valves, piping and appurtenances will follow the requirements of the Tract C-a lease and recommendations and standards of the American Petroleum Institute (API).

Tanks will be enclosed by dikes designed to form spill-containment basins. Interior surfaces of the dikes areas will be impermeable. The diked areas will be large enough to contain 150% of the volume of the tank(s) enclosed plus the volume of trapped precipitation that might be impounded at the time of a spill.

Each area will be designed for drainage away from the tanks into a gathering basin. The drainage from these diked areas will enter the process facility storm drainage system and pass through an API oil separator. The reclaimed water will then be used to cool and moisturize processed shale. Any oil present will be removed from the water and returned to the oil handling system.

Catchments will be constructed in any natural drainageways immediately downhill from the oil storage facilities so that should oil find its way outside the containment facilities, it can easily be controlled before it reaches a water course.

B. Handling of Pesticides - Insecticides, rodenticides and herbicides are often used on construction sites to protect health and safety of employees, maintain a pleasant environment and reduce maintenance and fire hazards. Rodents are often attracted to construction sites, necessitating the use of dangerous rodenticides.

Herbicides, rodenticides and pesticides are not contemplated for general use on the project, and their use will require prior approval of the Area Oil Shale Supervisor. Clearance for use of many of these chemicals is also required by restrictive Federal, State and local regulations.

If the need for use should arise, an awareness of the need to adhere to recommended dosages, type of application equipment, time of application, cleaning of application equipment and safe disposal of these chemicals will be instilled in employees and contractors engaged in these activities. The disposal and storage of pesticides and pesticide containers will conform to recommendations set forth in applicable Federal, State and local laws and regulations and the procedures promulgated recently by the Environmental Protection Agency.

7.3 SPILL CONTINGENCY

The following are guidelines designed to provide procedures and assistance in the preparation of detailed spill contingency response plans. The alerting and action flow procedure will conform in general to Figure 6-7-1, although some of the titles of various jobs descriptions may change when the organizational structure for the project is finalized.

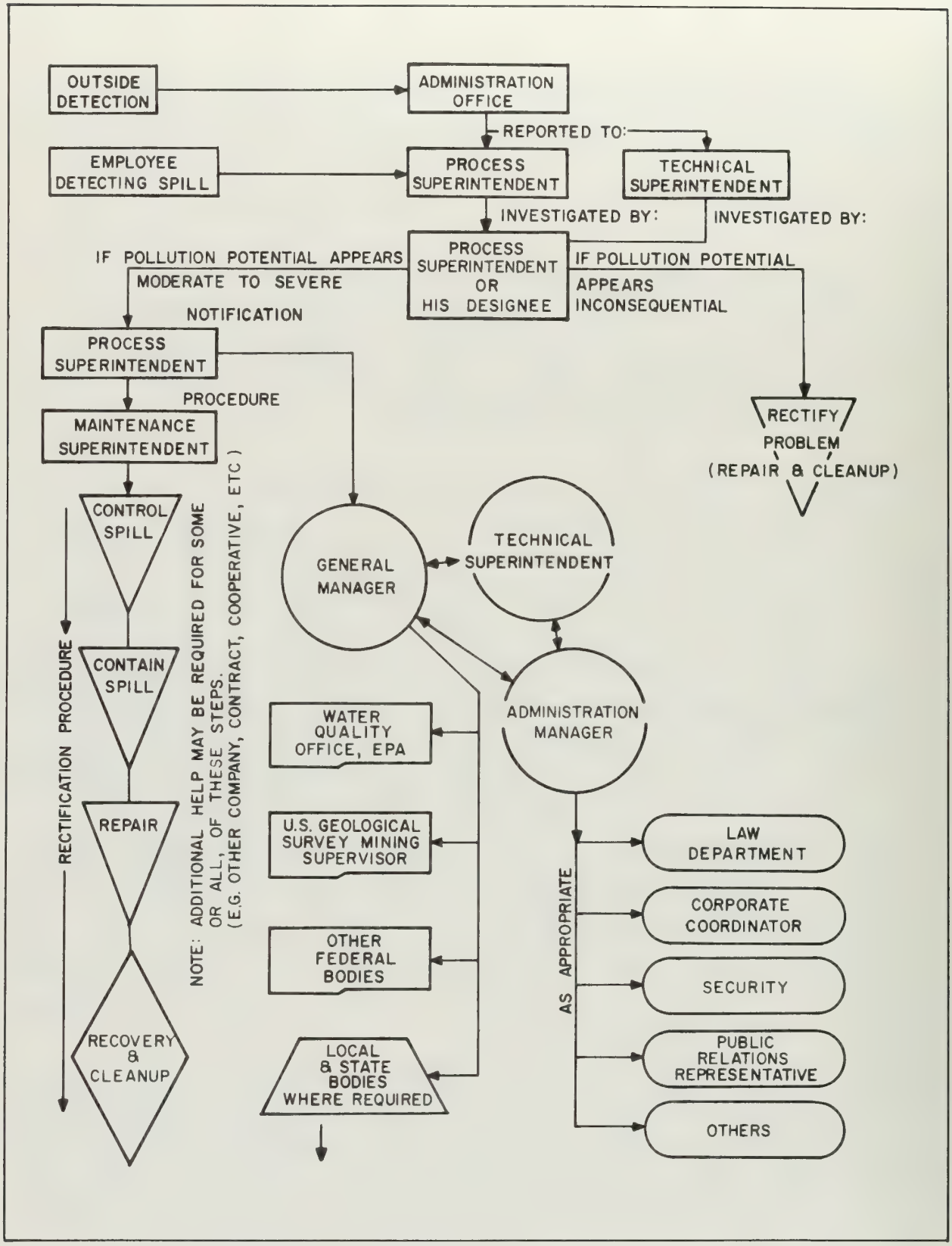


Figure 6-7-1

ALERTING AND ACTION PROCEDURE

A. Nontransportation - Related Facilities

1. Discovery and System Shutdown - The detection of leaks, overflows and miscellaneous spillage will be a part of the standard operating and maintenance procedures for the project. To the extent practical, automatic controls will be installed on all units that will operate in a fail-safe manner thereby minimizing dependence on the human element. Indicating, recording, and controlling devices monitoring pressures, temperatures, and flow rates will be integrated with all processing equipment. In addition, alarms and shutdown systems will be used to warn of unusual process conditions and shut down operation before equipment failure can occur. Visual inspection of all equipment will be on a routine scheduled basis.

2. Notification - When a spill is observed, alerting actions and reporting procedures will immediately be set in motion. The reporting procedure and level of authority to be notified will depend on the magnitude and sensitivity of the area of occurrence.

a. Reporting to Federal and State Agencies - Federal and Colorado regulations require immediate reporting of spills that enter streams or could pollute either surface or ground water. Once the maintenance superintendent has confirmed the occurrence of a reported spill and action has been initiated to control the spill, the following agencies will be notified:

- Area Oil Shale Supervisor, U. S. Geological Survey, Grand Junction, Colorado
- Region VIII, Office of EPA, Denver, Colorado
- Colorado Department of Health, Denver, Colorado
- Bureau of Land Management, Craig, Colorado

b. Internal Reporting - Regulations set a definite procedure for external notification. However, internal reporting can vary with

the size of spill and significance of response requirements. Due to the number of people to be notified and the need for simultaneous initiation of response action by local supervisors, delegation of alerting duties is required. This progressive alerting and action procedures is demonstrated on Figure 6-7-1.

3. Information Gathering - Certain information pertinent to planning the response to a spill occurrence must be gathered from the reporting source. This information is generally covered in the following listing:

- Material spilled.
- The time a spill started or was first observed.
- The location where the spill occurred and the present estimated spread rate.
- An estimate of the amount spilled or rate of release if the spill is continuing.
- The environmental conditions, including temperature, wind direction and speed.
- A description of the area likely to be affected, such as water sources and wildlife areas.
- The circumstances leading to the spill.
- The action being taken to respond to the spill and by whom.
- The agencies or other persons already notified.

4. Manpower, Equipment and Material Availability - The contingency plan will provide listings of manpower, equipment and material availability from project sources and from outside contractors, other companies in the area and the parent companies as applicable.

5. Containment - Except where preconstructed diking systems are provided, men, equipment and supplies will have to be transported to the scene of the spill as quickly as possible to implement containment procedures. Although each spill will call for individual techniques, the general methods described below are applicable:

- Source control - This involves the closing of valves and shutting down of equipment and immediate repair of damaged facilities or those causing leaks even if temporary.
- Spread control - Control to keep spill from spreading outside an area of containment can be effected by: construction of dikes and diversion ditches; spreading of absorbents; or use of chemicals to disperse or coalesce spills on water. (This last technique requires special approval of Federal and State agencies.)

6. Removal - Removal of spilled material, absorbents and the associated debris will be initiated immediately following the implementation of the containment procedures outlined above. Immediate removal is important since the cleanup may take several days, and changing weather conditions or equipment malfunctions may expand a controlled spill unless removal of spill is made as early as practicable. Specific removal methods will be developed. The preferred method of disposal of the removed oil or other hazardous material is delivery of it to a processing facility. Other available methods include: burning in place; absorbing and burning; absorbing and burial in an approved landfill.

7. Cleanup and Restoration - After removal of the spilled material, cleanup of the contaminated area may involve the removal of soaked soil, debris and contaminated vegetation. Additional cleanup can be effected by scrubbing soiled structures with detergent solutions. The extent of cleanup should balance potential ecological damage from the cleanup operations against the potential ecological damage of allowing some of the spill residue to remain for natural biodegradation. Contaminated soils will normally be disposed of in an approved landfill.

B. Transportation-Related Facilities - This section describes the oil spill contingency plan for spills related to the product pipeline. Procedures for coping with all phases of the accident including notification procedures, containment of the spill, cleanup and repairs are described.

The primary objective is to prevent, as far as practical, any damage from an oil spill to persons, property, flora and fauna.

1. Responsibility and Notification - All oil leaks, whether reported by employees, aerial patrol, land owners along the right-of-way, and others, or from the pipeline's operational data shall be investigated immediately by the process superintendent.

Oil spills having no pollution potential shall be rectified immediately (repaired and cleanup made) by the process superintendent with the help of the maintenance superintendent, if needed. Oil spills having a pollution potential shall be reported immediately to the general manager.

Based on oil spill data received, the general manager will decide which agency or agencies should be notified and through proper reporting channels will notify the appropriate agencies.

A Pipeline Carrier Accident Report, Figure 6-7-2, must be sent to the Department of Transportation in the event of any of the following:

- Explosion or fire not intentionally set by the carrier.
- Loss of 50 or more barrels of liquid.
- Escape to the atmosphere of more than five barrels a day of liquefied petroleum gas or other liquefied gas.
- Death of any person.
- Bodily harm to any person resulting in one or more of the following:

    - Loss of consciousness.
    - Necessity to carry the person from the scene.
    - Necessity for medical treatment.
    - Disability which prevents the discharge of normal duties or the pursuit of normal activities beyond the day of the accident.

GUS 30773

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION
PIPELINE CARRIER ACCIDENT REPORT

FORM APPROVED
BUDGET BUREAU NO.
004R5601

Instructions →

Complete in duplicate. If the space provided for any question is not adequate, attach an additional sheet. Definition of a reportable accident is stated in the Code of Federal Regulations, Title 49, Chapter 1, Part 195. File both copies of this report within 15 days after discovery of the accident with the Administrator, Federal Railroad Administration, Department of Transportation, Washington, D. C. 20591 (Refer: Sec. 195.54). Detailed instructions for preparing this form are found in Part 195. Specimen copies of this form will be supplied upon request without charge. Additional copies may be reproduced using the same format and size.

A Carrier Information

1. NAME OF CARRIER

2. PRINCIPAL BUSINESS ADDRESS

B Time and Location of Accident

1. DATE (MONTH, DAY, YEAR)
2. HOUR ☐ AM ☐ PM
3. LOCATION (STATE, COUNTY, CITY)
4. PART OF CARRIER'S SYSTEM INVOLVED
☐ LINE PIPE ☐ PUMPING STATION ☐ DELIVERY POINT
☐ TANK FARM ☐ OTHER (SPECIFY) _____
5. PHYSICAL LOCATION (IF LOCATION IS NEAR PUBLIC OR PRIVATE BUILDINGS, OR OTHER SIGNIFICANT LANDMARKS SUCH AS HIGHWAYS OR RAILROADS, ATTACH A SKETCH OR DRAWING SHOWING RELATIONSHIP OF ACCIDENT LOCATION TO THESE LANDMARKS)

C Origin of Liquid or Vapor Release

☐ PIPE ☐ GIRTH WELD ☐ LONGITUDINAL WELD ☐ PUMP ☐ VALVE ☐ SCRAPER TRAP
☐ METER OR PROVER ☐ TANK ☐ WELDED FITTING ☐ BOLTED FITTING
☐ SAMPLE HOUSE ☐ HAY TANK ☐ STRAINER OR FILTER ☐ OTHER (SPECIFY) _____

D Cause of Accident

☐ CORROSION ☐ DEFECTIVE WELD ☐ INCORRECT OPERATION BY CARRIER PERSONNEL
☐ DEFECTIVE PIPE ☐ EQUIPMENT RUPTURING LINE ☐ OTHER (SPECIFY) _____

E Death or Injury

1. NUMBER OF PERSONS KILLED		2. NUMBER OF PERSONS INJURED	
CARRIER EMPLOYEES	NON-EMPLOYEES	CARRIER EMPLOYEES	NON-EMPLOYEES

F Property Damage

1. CARRIER'S DAMAGE (PHYSICAL PROPERTY DAMAGED) $
2. ITEMS DAMAGED
3. OTHER PROPERTY DAMAGE $
4. ITEMS DAMAGED

G General Information

1. COMMODITY BEING TRANSPORTED AT TIME OF ACCIDENT	2. ESTIMATED LOSS DUE TO ACCIDENT BARRELS	3. YEAR FACILITY INSTALLED (EXCLUDING PIPE)	4. WAS THERE A FIRE? ☐ YES ☐ NO	5. WAS THERE AN EXPLOSION? ☐ YES ☐ NO

Instructions → *Answer sections H, I or J only if they apply to the particular accident being reported.*

H Occurred In Line Pipe

1. NOMINAL DIAMETER IN.	2. WALL THICKNESS IN.	3. GRADE	4. YEAR OF INSTALLATION ☐ BEFORE 1920 ☐ 1920-30 ☐ 1930-35 ☐ AFTER 1935 (SPECIFY YR.) _____	5. CONDITION WHEN INSTALLED ☐ NEW ☐ RECONDITIONED	6. TYPE OF JOINT ☐ WELD ☐ COUPLED ☐ THREADED

7. CONFIGURATION AT POINT OF ACCIDENT ☐ STRAIGHT ☐ SAG ☐ OVERBEND ☐ SIDEBEND	8. PIPE WAS ☐ COATED ☐ NOT COATED	9. PIPE WAS ☐ ABOVE ☐ BELOW GROUND

10. COVER, IF BELOW GROUND IN.	11. DESIGN PRESSURE PSIG	12. PRESSURE AT TIME & LOCATION OF ACCIDENT PSIG	13. HAD THERE BEEN A PRESSURE TEST ON SYSTEM? ☐ YES ☐ NO

14. IF 13 IS *YES*, MEDIUM USED ☐ WATER ☐ PETROLEUM ☐ AIR	15. DURATION OF TEST HRS	16. MAXIMUM TEST PRESSURE PSIG	17. DATE OF LATEST TEST

DOT Form 7000-1 (10-70)

Figure 6-7-2

PIPELINE CARRIER ACCIDENT REPORT

I Caused by Corrosion	1. TYPE OF CORROSION ☐ INTERNAL ☐ EXTERNAL	2. FACILITY COATED ☐ YES ☐ NO	3. FACILITY UNDER CATHODIC PROTECTION? ☐ YES ☐ NO	4. TIME BETWEEN CORROSION TESTS MONTHS	5. TYPE OF TEST USED
J Caused by Equipment Rupturing Pipeline	1. DISTANCE TO CLOSEST LINE MARKER	2. INFORMATION ON MARKER			3. LENGTH OF TIME BETWEEN PATROL ON SECTION DAYS

ACCOUNT OF ACCIDENT BY RESPONSIBLE OFFICIAL OF CARRIER

NAME AND TITLE OF CARRIER OFFICIAL FILING THIS REPORT	TELEPHONE NO. (INCLUDE AREA CODE)	DATE

Figure 6-7-2 (Continued)

PIPELINE CARRIER ACCIDENT REPORT

- Property damage of at least $1,000 to other than the carrier's facilities, based upon actual cost or reliable estimates.

A notice by telephone is required at the earliest practicable moment following discovery of a spill in the event the spill:

- Caused a death or a personal injury requiring hospitalization;
- Resulted in either a fire or explosion not intentionally set by the carrier;
- Caused estimated damage to the property of the carrier or others, or both, of a total of $5,000 or more;
- Resulted in pollution of any stream, river, lake, reservoir, or other similar body of water that violated applicable water quality standards, caused a discoloration of the surface of the water or adjoining shoreline, or deposited a sludge or emulsion beneath the surface of the water or upon adjoining shorelines; or
- In the judgment of the carrier, was significant even though it did not meet the criteria of any other subparagraph of this paragraph.

In addition to the Department of Transportation, when a spill of any kind occurs which does or may reach any waters of the state, surface or underground, the spill will be reported at once to the following:

- Colorado Water Pollution Control Division, Denver, Colorado, Phone: (303) 388-6111, Ext. 231
- Area Oil Shale Supervisor, U. S. Geological Survey, Grand Junction, Colorado
- Environmental Protection Agency, Denver, Colorado, Phone: (303) 837-3880
- Bureau of Land Management, Craig, Colorado

Spills which occur in sloughs, ponds, or other surface waters where there is any possibility of harm to fish or aquatic life and spills occurring on land where there is any possibility of harm to game or wildlife habitat will be reported as well to the State Division of Wildlife.

If it appears that domestic water users downstream may be affected, then immediate notification to these users will be made. Notification will be accomplished by contacting the local mayor, water superintendent, city engineer, city police, town marshall, sheriff's office, etc. In the event that the spill is near or over a road or highway and it is necessary to reroute traffic, the Colorado State Patrol will be alerted at once.

2. Locate and Identify Source of Discharge - The precise physical location of the source of the oil spill must be determined immediately. Company personnel receiving a report of a leak will obtain all available pertinent information. A standard leak report form will be used for receiving and recording information.

Reports of leaks are often received from outside parties who are unfamiliar with the operations of the company or with terminology used in the business. Often such reporters are vague as to location. Such persons will be questioned fully to: locate the leak in respect to a known landmark; obtain accurate and adequate information as to the nature of the leak; and obtain information as to conditions at the leak site. The source of discharge will be plotted accurately with reference to known areas on the pipeline route map.

This information is valuable not only in accurately locating the leak, but, also, to assist repair crews in selecting repair and containment equipment to be dispatched to the site.

The process superintendent will be notified immediately and furnished with all available information so that he can stop the leak and arrange

for maintenance crews and equipment to be dispatched to the site as quickly as possible. If the physical location or extent of the leak cannot be determined readily, experienced personnel will be sent to the scene, and if necessary, arrange for aerial patrol flights over the suspect area.

3. Stop Discharge - Prompt action in stopping the discharge or reducing the flow to an oil spill can be the difference between an incident of minor importance and a major accident. In the case of an oil spill or leak, the line will be shut down immediately if not already automatically shut down.

As soon as the location of the leak is determined, appropriate action will be taken to stop the discharge of oil at the point of the leak. This may require temporary repairs and isolation of sections of the line to prevent drainage of the pipeline or pumping down the section containing the leak.

4. Contain Spill - Containment of the spilled oil will be a concurrent activity with the stoppage of discharge. Oil may be contained in bell holes, or through the construction of catchment basins, earthen dams, separators, weirs, or other appropriate means.

Natural avenues of escape such as streams, waterways, ditches, and gullies will be followed on foot to determine that oil has not passed on or through them. If oil is found, containment facilities will be constructed. In some cases, such facilities must be constructed well ahead of the actual oil movement, if it is apparent that the oil will reach that point before containment facilities are constructed.

Contained oil will be picked up as quickly as possible to prevent further movement of the oil and to reduce hazards. Any appropriate means such as suction tank trucks, pumps, skimmers and floating booms will be used for cleanup from water surfaces.

5. Evaluate and Cope with Hazards - In order to minimize possible bodily injury, loss of life, property damage, loss of wildlife, or air or water pollution, time is of the essence in making an accurate analysis of hazards and potential hazards. All existing or potential hazards must be identified according to basic nature. There may be other hazards besides the obvious ones of fire, explosion, and pollution.

Oil discharges in congested areas, waterways, and watersheds draining into streams or impoundments from which private or public potable water supplies are drawn will require special precautionary measures.

When an oil spill poses an immediate or potential threat or hazard to the properties of third parties, these parties will be notified and consulted in any decisions which might affect their operations or facilities.

6. Repair and Cleanup - Repair will be started as soon as possible after the work area is judged to be safe and after all necessary precautionary measures have been satisfied. Repair and oil recovery should proceed simultaneously and must be closely coordinated. Cleanup operations should be prompt and thorough in all respects and will be completed as stated previously.

7. Evaluate and Complete Reports - A thorough analysis and report will be made of circumstances and handling of each oil spill. The experience gained from each such occurrence provides the best guideline for updating the contingency plan to handle future oil spills. Follow-up actions are extremely important and will include such items as training of personnel, assessment of equipment and evaluation of policies and procedures.

C. Contingency Plan for MIS Underground Pump Room - Contingency planning for the MIS underground oil/water pump room will follow the following guidelines:

1. Design Guidelines

- Underground oil and water pipe tunnel will be constructed with positive grade away from the pump room so that any spills from piping between the underground pump room and the surface will drain toward the pump room.
- Emergency sump with pumpout equipment will be located near the pump room to accept drainage from the pipe tunnel or from spills occurring in the pump room.
- Escape facilities (cage and ladders, escape capsules) will be provided in ventilation shaft from the pump room to the surface.
- Automatic control, recording, alarm and shutdown systems will be provided for pump room equipment to monitor flows and to detect and alert operating personnel to spills.
- Sealing door will be provided to close off access between mine and pump rooms or pipe tunnels.

2. Operating Guidelines

- Access for operation personnel to the pump room will be monitored and controlled.
- Use of protective equipment by operating personnel when in the pump room will be required.
- Use of reporting and information gathering procedures when a spill in the pump room is detected will be established.

3. Spill Response Guidelines

- Procedures for evaluating the severity of the spill and implementing corrective action (which may include shutdown of equipment upstream and downstream of the pump room) will be established.
- Initiation of spill removal and cleanup procedures immediately following implementation of corrective action will be required.

CHAPTER 8

LAND REHABILITATION & EROSION CONTROL

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER 8

LAND REHABILITATION AND EROSION CONTROL

This chapter discusses rehabilitation in terms of the environmental concern for the return of disturbed lands to a condition compatible with the stated purposes of the Tract C-a lease. Section 4 discusses processed shale and development ore disposal. The objectives of the land rehabilitation program described in this chapter are to reclaim disturbed areas by returning them to a state consistent with pre-existing land uses in the area and compatible with existing adjacent undisturbed natural areas.

The overall concept of rehabilitation efforts for the project includes numerous problems and considerations dealing with mining, access, plant sites, parking lots, conveyor corridors, access roads, transmission lines, pipelines, etc. The principal elements considered in this chapter are site preparation, erosion control and revegetation.

8.1 AREAS AFFECTED

Table 6-8-1 shows estimates of the yearly disturbed surface areas on Tract C-a and areas ready for rehabilitation for the Modular Development and Commercial Phases. The Rangely access road, power line and telephone facilities, located off-tract, are excluded because they will be constructed and rehabilitated by other entities, i.e., Rio Blanco County, Moon Lake Electric and Mountain Bell.

8.2 SITE PREPARATION

Site preparation, or the shaping and grading of areas being rehabilitated, is determined by three primary environmental concerns: erosion control, aesthetics and species to be planted. Another factor influencing the

Table 6-8-1

ESTIMATED ACREAGES OF LAND SCHEDULED TO BE DISTURBED AND REVEGETATED ON TRACT C-a

DISTURBED

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987-1991	1992-1996	1997-2001	2002-2006	2007-2011	2012-2016	TOTAL
Mine and Plant Sites	34				26	218										278
Run of Mine Disposal Area	65															65
Crushed Ore Disposal							130	130								260
Corridors	100	12			21	39				104						276
Processed Shale Disposal Pile									70	320	210	40	240			880
	199	12			47	257	130	130	70	424	210	40	240			1759

RECLAIMED

Run of Mine Disposal Area						15	20	30								65
Crushed Ore Disposal									200						60	260
Corridors		80	12			21	32			104						249
Processed Shale Disposal Pile											20	215	215	215	215	880
		80	12			36	52	30	200	104	20	215	215	215	275	1454

rehabilitation work is the method chosen to construct an artificial soil profile on the processed shale disposal pile to facilitate revegetation. Chapter 10 of this section covers aesthetics, and erosion control is discussed in part 8.3 of this chapter.

A. Soil Conservation - Soil is considered an important natural resource in the Piceance Creek basin. Surface soil and soil like material will be stripped from all disturbed areas and stockpiled for later use in revegetation.

Soil excavated for roadway construction operations will be stockpiled in selected areas along the alignment for reuse to cover cut-and-fill slopes. Soils excavated from the mine service area and processing area will also be excavated and stockpiled in an area where it can be reused later.

In the development ore and processed shale disposal areas, soil will be stockpiled and used as required. At that time, nutrients will probably be added in order to restore fertility in the soil.

Larger pieces of rock may be placed on the disposal pile to enhance the aesthetics by breaking up uniform lines and surfaces and also to control erosion.

B. Artificial Soil Profile - The development ore disposal piles (run of mine, ROM, and crushed ore) will not require an artifical soil profile, only the addition of previously stockpiled soil.

Soluble salts in the processed shale, if uninhibited, may migrate by capillary action to the surface during the summer months. It is anticipated that the salt would be deposited near the ground surface and form an alkaline environment unfavorable for plant growth. Continuous maintenance activity in the form of leaching and irrigation would be required to successfully revegetate processed shale that is covered with only the small amount of soil available.

To avoid the necessity for extensive leaching of salts from the surface of the processed shale pile, an artificial soil profile will be developed. This artificial soil profile will consist of a layer of rock to prevent capillary movements of moisture from the processed shale upward toward the root zone. The rock will be covered with soil. Upward moisture migration in the liquid phase is not anticipated across the rock layer. However, the rock layer will not interfere with the movement of small amounts of moisture in the vapor phase, and additionally will prevent soluble salts from migrating toward the surface. Figure 6-8-1 illustrates a cross section of the processed shale disposal pile with the artificial soil profile in place. For more information on the individual layers of the artificial soil profile see Part 8.4 of this section. It is anticipated that sufficient soil and soil like material will be available to apply a 12 inch (30 cm) layer over the entire surface of the processed shale pile.

Our concern in using the artificial soil profile on top of the processed shale is retention of sufficient soil moisture for the year's growth of vegetation. The water-holding capacity of Tract C-a soils which will be stockpiled for reclamation use is equal to or greater than 7% (RBOSP Final Environmental Baseline Report, 1977). This water retention capacity is considered to be the minimum capacity to insure a soil potential adequate to retain sufficient water for normal plant growth (Nishimura, 1974). In addition, the average topsoil depth on Tract C-a is approximately 32 cm (RBOSP Final Environmental Baseline Report, 1977). The surface soil layer of the artificial soil profile will be approximately 30 cm in depth which is similar to the average depth of soils on Tract C-a. Of the three factors determining water-holding capacity (soil texture, structure and organic matter), only soil structure will be affected by stripping and stockpiling. Therefore, the artificial soil profile is expected to retain sufficient moisture to insure successful plant germination and growth.

The artificial soil profile described above will be constructed initially, but as more is learned about the revegetation of processed shale, it may

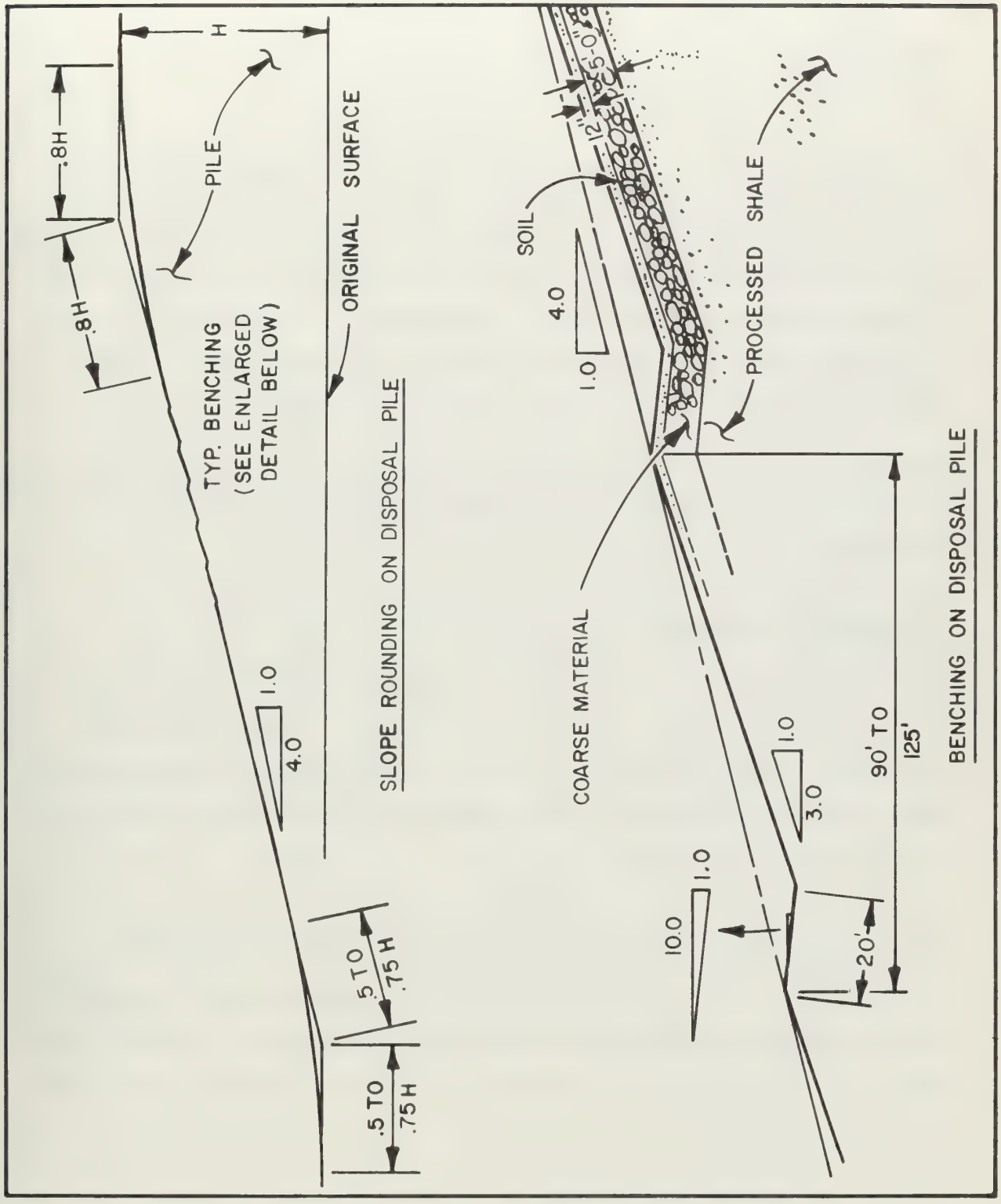


Figure 6-8-1

DISPOSAL PILE CROSS SECTION

become desirable at some future time to change the artificial soil profile to obtain the desired results more effectively.

8.3 EROSION CONTROL

Erosion is a process by which the land surface is worn away by the action of water, wind, ice or gravity. Although erosion occurs naturally as part of the weathering cycle, it is accelerated by mining and construction activities. Physical disturbance exposes materials to erosion mechanisms and increases the rate of erosion. Moving water is responsible for most erosion; however, wind erosion is also a significant factor. Gravity and ice will not be of major importance to the project.

The following paragraphs deal mainly with erosion by water; however, treatments to prevent water erosion and sedimentation are also equally applicable to wind erosion.

A. Material Size and Classification - Gravelly soils and/or boulders are not likely to erode. Undisturbed clay particles, although very small, are usually erosion resistant because of bonds produced by electrical imbalances within the unit cells of the soil particles. Most soils on the tract and the waste materials fall somewhere between these two limits. Processed shale would nominally be classified as silt, an easily erodible material.

Soil erodibility can be rated according to grain size (percent of silt and very fine sand), structure, permeability and organic matter. A given material will be more resistant if it can be made more permeable (more infiltration and less runoff). The least desirable combination of materials from an erosion resistance point of view is a high range (30 to 70%) of silt and very fine sand. One of the most basic and obvious erosion control measures applicable to all slopes is the use of a coarse material as a cover layer. The longer and steeper the slope, the thicker should be the layer of material.

B. Slope and Surface Treatment - Slope roughening practices, such as scarification and furrowing slopes along contour, will be used to decrease runoff, as well as to slow the water movement. These practices reduce the ability of moving water to detach soil particles and transport sediments. Some of the proposed practices include:

- Slope roughening by scarification along the contour of a graded slope. The grooves spread the runoff horizontally, slow its movement downslope and increase the infiltration rate. Roughening is also beneficial in the establishment of vegetation on a graded area. This practice also increases moisture retention and loosens the soil in the plants' root zone. The horizontal grooves retain soil additives, seeds and mulch that might otherwise be washed down the slope.
- Operating a bulldozer up and down a graded slope. This practice is referred to as "tracking" and is more adaptable to steep slopes than scarification. "Tracking" does not loosen the soil as much as scarification, and the resulting compacted soil may be more beneficial on long or steep slopes exposed to high intensity rainfall.
- Pockets developed on slopes at varying intervals.

All other factors being equal, a long slope will collect more runoff than a short slope. The greater concentration of water at the base of the longer slope increases the likelihood of erosion. To minimize this problem, long slopes will be constructed to function as a series of short slopes by utilizing diversion features, such as benches, terraces, ditches or dikes. Benching, shown on Figure 6-8-1, is planned for disposal piles. The benches will be carried laterally to a point where drainage can be emptied into a riprapped channel, which will carry the water off the slope.

Selective spreading of individual large rocks may be included in this treatment to provide energy dissipation and shade for new plants, and to break up regular structural lines and improve the appearance.

C. Drainage - Facilities will be provided to drain interception ditches and benches, and to direct the flow of water into erosion resistant areas or into specially designed channels. The basic drainage elements will be interception ditches, dikes and channels.

As required, a number of special disposal structures will be used including drain pipes, down drains, chutes and flumes. These disposal structures will be designed to handle the water and sediments that occur as a result of an unusually heavy downpour on bare soil areas. They will be designed for both permanent and temporary use.

Water bars and breaks will be constructed to divert water from unsur faced roadways into natural drainage. To keep flows in road ditch sections from reaching dangerous proportions, cross drains will be installed in addition to regular drains. The following table as per BLM specifications provides a general guide for spacing both water bars and cross drains. Flow velocities will be controlled by energy dissipation devices, such as check dams, plunge pools and rock weirs.

WATER BAR AND CROSS DRAIN SPACING

Road Gradient (%)	Distance Between Water Bars and Cross Drains (ft)
Less than 2	200
2 to 4	100
4 to 5	75
5	50

D. Temporary Measures - Temporary erosion control measures will be provided as required at all sites where grading has been done and revegetation has not been completed. Shielding and/or protecting the soil can be accomplished in different ways. A wide variety of products is available commercially, and some materials can be found locally.

1. Cover Material - Choosing the best cover material is a matter of convenience, cost, ultimate purpose and effectiveness. When the cover material is applied as an initial step in revegetation, it should

also have good mulching characteristics. Some of the materials that are being considered for this project, their application rates and special conditions are listed below:

- Straw (2 tons per acre) - Straw is versatile, effective, easily obtained, but is susceptible to wind damage.
- Emulsions (500 to 800 gallons per acre) - Emulsions provide a quick, effective cover and are normally effective in wind. It is often combined with straw to provide good ground cover.
- Chemical binders - Various sprays of dust stabilizing agents or glue-like substances can be used. These binders generally penetrate into the surface of the soil before they set, combining with individual soil grains to form a mat.
- Cellulose fibres (1 ton per acre) - Cellulose fibres can be applied using hydroseeding techniques.
- Jute netting and mats - Jute netting and mats are temporary but quick and easy to apply as a good, instant ground cover.
- Plastic matting and nets - Normally they give an excellent lasting cover and the vegetation will normally grow through the material openings.

The advantages and disadvantages of various mulching materials are discussed in 8.4 of this chapter. Obviously there are many products not included above that will prove to have special value. Chemicals and emulsions that have been tested on highway cuts and fills as well as waste piles include: silicates, lignosulphates, pyrite treated with sulphuric acid, cement, lime, cationic neoprene emulsions, elastromeric polymers, resinous material, bituminous base products, cellulose compounds, various oil fractions, amines, waxes, tar and pitch emulsions. Special problems will require a careful evaluation of materials and sometimes field testing of several to obtain satisfactory results.

2. Cover Criteria - While slopes are under construction, enough temporary cover material, of the kind quickly applicable in any weather, will be kept on hand to cover erodible exposed slopes whenever necessary. Surface roughness of the slopes will also help prevent erosion.

Seeding and plant operations are restricted seasonally, and slopes constructed between seasons will be quite vulnerable to erosion. Temporary cover of some slopes is needed depending upon exposure, material, surface areas, steepness, etc. The following table indicates generally the criteria for application of temporary cover material or mulch on various sloped surfaces.

Slope	Cover Criteria
10%	If the run[1/] exceeds 8 feet
6 - 10%	If the run exceeds 12 feet
3 - 6%	If the run exceeds 25 feet
0 - 3%	If slopes have been scarified or perforated adequately to retain all moisture in surface depressions, generally no cover is required except for specific, unstable, or highly hazardous conditions.

[1/] "Run" is defined as the maximum length that water will travel without provision of some form of retention.

Slope areas, consisting of over 50% of loose rock, talus or other blocky material, will not normally require temporary covers.

The nearly horizontal portion of benches with reverse back slopes will not be covered; however, the sloping portions of the benches will require protective measures.

The working faces of disposal piles will not normally receive any temporary cover, except that a temporary cover will be applied if necessary to prevent significant erosion whenever a slope has been completed, and revegetation cannot commence before the start of wet weather.

8.4 REVEGETATION

A. Introduction - Land disturbed by RBOSP mining development and operation on and in the vicinity of Tract C-a will have to be reclaimed. Areas will be disturbed by construction on the plant site, access roads, pipe-line, water control structures, and disposal of raw shale ore and processed shale. Methods of reclamation include revegetation, crop production, or covering disturbed areas with rock. Where feasible, revegetation provides the most self-sustaining and aesthetically acceptable means of rehabilitation.

In accordance with Section 11 of the lease stipulations, RBOSP will restore affected lands to a condition at least equal in quality to pre-existing land uses in the area and one that is compatible with adjacent undisturbed areas. The surface rehabilitation plan described herein details the RBOSP revegetation program which has been designed to successfully fulfill all lease requirements and to meet the reclamation performance standards of the Colorado Mine Land Reclamation Board. The revegetation program is based on available technology. Implementation of this program should ensure that all land disturbed by RBOSP mining activities is restored to conditions that are at least as good as pre-disturbance conditions. The reestablished vegetation will be of a quality to support the same kinds and number of fauna which presently exist in the vicinity of Tract C-a.

Baseline studies provided data on existing range trends, browse and soil conditions, and forage production. These conditions characterized the quality of existing vegetation on and near the tract. Baseline studies also determined the numbers and kinds of fauna that presently exist in the area. These data are presented in the RBOSP Final Environmental Baseline Report (1977). At present, land on and adjacent to Tract C-a is used primarily by cattle and wildlife. The present fauna includes mule deer, feral horses, domestic livestock, birds, small herbivores, and predators. Needs of these fauna can be provided on reclaimed areas by plant communities which have a species composition and productivity

similar to undisturbed areas and by habitat modifications planned as part of the Fish and Wildlife Management Plan (see Section 6, Chapter 11).

B. Revegetation Technology - The success of revegetation in the semi-arid West is limited by low soil moisture, the scarcity of suitable irrigation water, and by alkaline or saline soils. The use of proper reclamation planning and revegetation technology can largely eliminate, or at least minimize, some of these limitations.

The foothill zone of the Piceance Creek basin has a moderate potential for rehabilitation. This potential increases at higher elevations where precipitation is higher (Terwilliger et al., 1974). It is expected that all areas disturbed by the RBOSP operation can be successfully revegetated if suitable technology is used.

Revegetation accelerates natural succession because the annual weedy stage is largely avoided by seeding perennial grasses and forbs, thereby enhancing the invasion of desirable native perennial forbs (Terwilliger et al., 1974). Once perennials are established, natural secondary succession may continue for 20 to 50 years (Terwilliger et al., 1974). The final species composition is impossible to predict and will depend on the available natural seed source in the area, climatic conditions during succession, grazing by domestic animals and wildlife and the composition of the planted species.

In contrast to reclamation of surface disturbances, the rehabilitation of the processed shale disposal areas will require greater effort. Processed shale has physical, chemical, and hydrological characteristics which may limit revegetation success (Striffler et al., 1974) and prevent the physical stabilization of the disposal piles (see Section 4). The processed shale requires extensive leaching before the salinity is low enough for plants to germinate and become established. Additional leaching may be necessary if salts migrate upward into the rooting zone, but may not be sufficient to remove toxic elements such as heavy metals.

Harbert and Berg (1974) have shown that the heavy metals zinc and molybdenum may concentrate in vegetation to levels which are known to be toxic to cattle when ingested. Substrate temperatures high enough to prevent normal seed germination may result from absorption of sunlight by the dark color of the processed shale (Schmehl and McCaslin, 1973).

Extensive studies have been done to determine successful means of revegetating processed shale (Berg, 1975; Block and Kilburn, 1973; Culbertson et al., 1974; Harbert and Berg, 1974; Lipman, 1975). Revegetation on processed shale is successful if the shale is leached to a depth suitable for plant growth and if adequate water and nutrients are available. It is not known if a long-term, self-sustaining plant community can be maintained without continuous management. An alternative to revegetating the processed shale directly is to cover the spoils with a non-toxic substrate, such as rock or soil, to provide a medium more suitable for plant growth. This alternative is planned for reclamation of the processed shale disposal pile on Tract C-a.

The artificial soil profile is designed to reduce the direct adverse effects of processed shale on plant establishment. The effectiveness of such an artificial soil profile is currently being tested as part of the RBOSP experimental revegetation program on Tract C-a. The first year's results of the 1975 RBOSP experimental program, other studies conducted in the Piceance Creek basin (Sims and Redente, 1974; Berg, 1975), and the success obtained in revegetating the drill pads on Tract C-a indicate that available technology is adequate to insure successful rehabilitation of surface disturbances in the vicinity of Tract C-a.

The following discussion outlines the revegetation methods that are most appropriate for reclaiming the lands which will be disturbed by RBOSP. The major types of disturbed lands that will require revegetation include:

- Areas disturbed by the mine and plant site, access roads, support facilities, water-control structures, and pipelines.
- Raw shale ore and processed shale disposal areas.

Since the processed shale disposal pile will be reclaimed by constructing an artificial soil profile rather than by direct revegetation of the processed shale, the approach described herein is generally applicable to both types of disturbed areas. Reclamation of both types of disturbed areas will therefore be discussed concurrently. The reclamation of the disposal piles will be more difficult.

1. Schedule - The mining and reclamation plans have been coordinated to assure the earliest feasible revegetation of disturbed lands. Table 6-8-1 presents the annual sequence of land disturbance and revegetation on Tract C-a throughout the life of the project. Construction which is scheduled for the first several years of the Modular and Commercial Phases will disturb the surface. Revegetation of all disturbed areas will begin 1 year after disturbance. Revegetation of the raw shale ore disposal piles will be delayed until all disposal of raw shale ore is completed. Reclamation of the processed shale pile in Rinky Dink Gulch will be a long-term effort. The 880 acre disposal area will be revegetated in segments during the 30-year operational period as sections of the pile are completed. Mining plans have been developed to minimize the area of exposed processed shale and therefore reduce the fugitive dust.

2. Seedbed Preparation - Debris and large rocks which might hamper operation of machinery will be cleared and the areas will be contoured to an overall slope of 4:1. The disposal piles will be terraced to reduce erosion and the individual terraces will have a 3:1 grade. Slopes steeper than 3:1 limit the use of machinery for seeding and increase the potential for soil erosion. In small areas, around buildings, and along haul roads where surface soils are not available, the subsurface soils will be scarified and furrowed to reduce erosion until suitable vegetation has been established.

Surface and suitable subsurface soils will be stripped from proposed construction and disposal sites and stockpiled for use in reclaiming the raw shale ore and processed shale disposal piles. Since stockpiled soil

may not be used for several years, the soil stockpiles will be mulched or revegetated with a quick-growing annual to reduce fugitive dust. The surface soils, and to a lesser degree the subsurface soils, of Tract C-a are suitable to support plant growth.

Soil studies in the vicinity of Tract C-a (RBOSP Progress Report 9, 1977) indicated that few chemical differences exist between surface and subsurface soils and that rockiness may be the primary factor limiting the use of subsurface soils as a suitable plant growth medium. Soil depth in the area of the disposal piles is shallow but measurements indicate that an average of 12 inches of material is available for stripping and stockpiling. Soil material (surface and/or subsurface soils) will be placed on the processed shale and raw shale ore disposal piles prior to revegetation.

The preparation of the seedbed on the processed shale disposal pile will be more extensive than seedbed preparation in surface disturbed areas. Preliminary designs of a typical disposal pile have the following strata, from top to bottom:

0.3 - 0.6 m (1/2 - 1 feet) of soil material	┐ Artificial
0.9 - 1.5 m (3 - 5 feet) of raw shale ore (0 - 8 inch size)	┘ soil profile
1.5 m (5 feet) of 95% compacted processed oil shale	
0 to several hundred meters of 80% compacted processed oil shale	
1.5 m (5 feet) of 95% compacted processed oil shale	

The values for the soil material and the layer of raw shale ore represent minimum ranges in depth for the artificial soil profile. Further details of the disposal pile preparation are included in Section 6, Chapter 8.2.

This artificial soil profile should provide an adequate quantity and quality of rooting medium to support plant cover and minimize direct root contact with the processed shale. The larger pore size of the crushed raw shale should reduce capillary movement of salts from the processed shale into the rooting zone. The size distribution of the

crushed raw shale ore is presented in Section 2, Chapter 6.4. In addition, the chemical characteristics of raw shale ore (C. McKell, Utah State University, personal communication, 1977) are not expected to inhibit successful plant establishment.

3. Seeding - Areas will be seeded as they become available for revegetation. In western Colorado, seeding has been successful in late fall or early spring, although late fall (September 15 to November 15) is generally preferable (Cook et al., 1974). Seeding on Tract C-a will be carried out during the optimal fall period unless disturbed areas will be available for revegetation in spring and would benefit from immediate revegetation. If large areas of the disposal piles are completed at times other than those preferred for revegetation, the raw shale ore layer, a mulch or a quick growing annual may be applied to reduce fugitive dust problems. Quick-growing annuals may also be used initially in the revegetation program to stabilize disturbed areas since they establish rapidly and provide a natural mulch for a subsequent seeding of native plants.

Since the RBOSP mining operation is expected to disturb land in several different vegetation types, the selected species mixtures will be specific for the climatic and physical conditions. Numerous studies have been conducted to investigate the performance and adaptability of various plant species in vegetation types typical of those on Tract C-a (Cook et al., 1974; Cook et al., 1970; Doran, 1952; Harbert and Berg, 1974; Hull and Doran, 1950; Merkel et al., 1972; Merkel and Currier, 1973; Plummer, 1970; Sims and Redente, 1974; USDA - Soil Conservation Service, 1974). Certain plant species have been successfully seeded in vegetation types occurring naturally in the vicinity of Tract C-a (Table 6-8-2).

In small surface disturbed areas, a composite mixture of grasses and forbs will be seeded. Shrubs are expected to invade from adjacent areas. In disposal areas, a composite mixture of grass, forb, and shrub species will be seeded to provide for more rapid introduction of browse and forage for domestic and wildlife species. Seeding of composite

Table 6-8-2

PLANT SPECIES RECOMMENDED FOR SEEDING IN VEGETATION TYPES OCCURRING WITHIN THE VICINITY OF RBOSP OIL SHALE TRACT C-a

Plant Species	Vegetation Type: Saltbush Scrub	Sagebrush Scrub		Pinyon-Juniper		Mountain Brush		Aspen
	South	North	South	North	South	North	South	North
Russian wildrye	x[a]		x[a]		x[a]		x[a]	x[a]
Indian ricegrass	x[a,c]	x[a,c]	x[a,c]	x[a,c]	x[a,c]			
Alkali sacaton	x[a,c]		x[c]					
Bottlebrush squirreltail	x[a]							
Crested wheatgrass	x[c]	x[a,b,c]	x[a,b,c]	x[a,b,c]	x[a,b,c]		x[a,b,c]	x[a]
Western wheatgrass			x[a]		x[a,b]		x[a,b]	x[a]
Bluebunch wheatgrass		x[a,c]	x[a,c]		x[a,c]			
Pubescent wheatgrass		x[a,b,c]		x[a,b,c]	x[a,b,c]		x[a,b,c]	x[a]
Intermediate wheatgrass		x[a,b,c]	x[a,b,c]	x[a,b,c]	x[a,b,c]	x[a,b]		x[a]
Streambank wheatgrass		x[a,b]		x[a,b]	x[a,b]		x[a,b]	
Tall wheatgrass		x[a]		x[a,b]		x[a,b]	x[a,b]	
Thickspike wheatgrass		x[b]		x[b]			x[a,b]	
Slender wheatgrass				x[a]		x[a]	x[a]	x[a]
Beardless wheatgrass							x[a]	x[a]
Bearded wheatgrass								x[a]
Sand dropseed			x[a]		x[a]			
Mountain brome		x[b]		x[a,b,c]		x[b,c]	x[b,c]	
Reager meadow brome		x[b]	x[b]	x[b,c]	x[b,c]	x[b,c]	x[b,c]	
Smooth brome						x[a,c]		x[a]
Green needlegrass		x[b]			x[a,b]	x[b]	x[b]	
Basin wildrye		x[a,c]				x[b,c]		x[a]
Hard fescue		x[c]				x[a,c]	x[a,c]	x[a]
Sheep fescue						x[a]	x[a]	
Arizona fescue						x[a]		
Idaho fescue						x[a]		
Orchard grass						x[a,c]		x[a]
Big bluegrass						x[a]		x[a]
Tall oatgrass						x[a,c]		x[a]
Meadow fescue								x[a]
Tall fescue								x[a]
Blue wildrye								x[a]
Canada wildrye								x[a]
Timothy								x[a]
Alfalfa	x[c]	x[a,b,c]		x[a,b,c]		x[a,b,c]	x[a,b,c]	
American vetch		x[a]		x[a]		x[a]		x[a]
Cicer milkvetch		x[a]	x[a]	x[a]		x[a]	x[a]	x[a]
Yellow sweetclover		x[a,b,c]	x[a,b,c]	x[a,b,c]	x[a,b,c]	x[a,b,c]	x[a,b,c]	
Utah sweetvetch		x[b,c]	x[b,c]	x[a,b,c]			x[a,b,c]	
Rocky Mountain penstemon		x[b]					x[b]	
Bouncing bet		x[b]		x[b,c]			x[b,c]	
Lewis flax		x[b,c]	x[b,c]	x[b,c]	x[b,c]		x[b,c]	
Arrowleaf balsamroot		x[c]			x[a,b,c]	x[b,c]	x[b,c]	x[a]
Palmer penstemon		x[c]			x[b,c]		x[a]	
Gooseberry globemallow			x[a]		x[a,b]			
Small burnet				x[b]				
Verbena					x[b]			
Sweetanise					x[b]			
Penngift crownvetch				x[b,c]	x[b,c]		x[b,c]	
Sicklepod milkvetch								x[a]
Winterfat	x[a,c]	x[b]	x[b]	x[b,c]	x[b,c]			
Four-wing saltbush	x[a]							
Shadscale	x[a]							
Nuttall saltbush	x[a]							
Greasewood	x[a]							
Green ephedra	x[a]	x[a,b,c]		x[b,c]	x[b,c]		x[b,c]	
Rubber rabbitbrush		x[a]						x[a]
Big sagebrush		x[a,c]	x[a,c]	x[a,c]	x[a,c]		x[a,c]	x[a]
Little rabbitbrush		x[a,b,c]	x[a,b,c]		x[a,b,c]		x[c]	
Bitterbrush		x[b,c]	x[b,c]	x[a,b,c]	x[a,b,c]	x[a,b,c]	x[a,b,c]	
Utah serviceberry		x[c]		x[a,c]			x[a,c]	x[a]
Stansbury cliffrose		x[b]		x[b]	x[b]		x[a,b]	
Curl-leaf mahogany				x[a,c]		x[a]	x[a]	
Mountain mahogany				x[a,c]			x[b,c]	
Common bladdersenna				x[b,c]			x[b,c]	
Black chokecherry				x[b,c]		x[b,c]		x[a]
Snowberry								x[a]
Aspen								x[a]

Recommended by:

[a] Cook et al. (1974)

[b] Sims and Redente (1974)

[c] Plummer (1970)

mixtures of grasses, forbs, and shrubs is expected to accelerate succession due to the potential early introduction and establishment of native plant species.

Direct seeding of shrubs in the fall of 1975 resulted in successful shrub establishment during 1976 (RBOSP Progress Report 9, 1977). These results of the RBOSP experimental program are encouraging and indicate that suitable wildlife habitat may be restored.

Native plant species are preferred because their use reduces the possibility of introducing undesirable exotic species. Exotic species will be considered when selecting seeding mixtures if the species can enhance stabilization. Because of the success already demonstrated with native species in the area (Sims and Redente, 1974), the use of exotic species may not be necessary for the RBOSP reclamation program. The final selection of seeding mixtures will depend on the adaptability of species to the environmental conditions of the disturbed area and on availability.

Seeds of native plants are not now readily available but, as more commercial firms become active in this area, their availability is expected to improve. The Soil Conservation Service (SCS) Plant Materials Center in Meeker is expected to develop new improved varieties of seed but the time necessary for such development is unknown.

Seeds will be broadcast or drilled depending on the terrain to be seeded. Drilling will be limited to terrain where machinery can be used. Drilling will be used on the disposal piles because the slopes will not exceed an overall 4:1 grade. The disposal piles will be terraced to reduce erosion hazard and individual terraces will have a 3:1 grade. Broadcasting may be necessary on steep slopes or in small areas where operation of equipment is not feasible or practical. In some areas where broadcasting is used, seed will be covered by soil with a harrow or disk. All seeded areas, if practical, will be compacted using a cultipacker to provide a more favorable germination medium.

The seeding rate will depend on site conditions and the growth form, (e.g., grass or shrub) of the seeded species. Seeding rates of 7 to 15 pounds of pure live seed (PLS)/acre will be applied to surface disturbance areas as suggested by Cook et al. (1974). The SCS recommended rate of 40 PLS/sq ft will be applied on disposal piles because they would be classified as critical planting areas (e.g. non-irrigated areas, etc.). Any broadcasted seed will be sown at a rate double that recommended for drilling.

In certain critical areas, direct seeding may not result in the establishment of shrub species. In these areas, it may be preferable to reestablish shrubs by using transplants. Containerized seedlings have recently received much attention (Tinus et al., 1974) because of their potential for rapid juvenile growth as a result of improved soil moisture conditions.

Field comparisons of direct seeding of shrubs to containerized seedlings are currently being conducted by RBOSP. In addition, the "Vermeer" tree spade (Dressler and Knudson, 1976) is currently being tested by governmental agencies to evaluate its feasibility for transplanting shrubs and trees. These methods and any future developments will be considered when revegetation plans are finalized.

4. Mulches - Numerous mulches have been developed and tested to determine their suitability under different conditions. Advantages and disadvantages of some common mulches and their use in combination with artificial soil coverings or mattings are listed in Table 6-8-3.

Straw will be used most often because of its demonstrated success (Table 6-8-3), availability, and lower cost. Straw will be anchored or used in combination with a soil covering, such as plastic or jute netting, to keep the mulch intact and in place. An application rate of 2 tons/acre will probably be used since it has been successful in other areas (Beard, 1966; Meyer et al., 1970). The specific mulch to be used during reclamation will depend on the slope and size of the disturbed area. Table 6-8-3 indicates the appropriate mulch to be used under various conditions.

Table 6-8-3

ADVANTAGES AND DISADVANTAGES OF SOME COMMON MULCHES AND SOIL COVERINGS AVAILABLE FOR USE ON DISTURBED AREAS IN THE VICINITY OF TRACT C-a

Mulch Type	Advantage	Disadvantage	Studies or Review
Straw (crimped)	High moisture retention, low erosion, readily available, relatively inexpensive	Contamination by weed seeds Susceptibility to fire	Springfield (1971) Beard (1966) Barnett et al. (1967) Dudeck et al. (1970)
Hay (crimped)	High moisture retention, low erosion, readily available, relatively inexpensive, usually less weed seeds than straw	Contamination by weed seeds Susceptibility to fire	Springfield (1971) Beard (1966) Barnett et al. (1967) Dudeck et al. (1970)
Straw plus asphalt	Effectively conserves moisture	Susceptible to wind and water erosion	Cook et al. (1970) McCully and Bowmer (1969)
Straw plus jute netting	Very effective for steep slope if applied correctly	May cause slope to slide and create gullies if applied incorrectly; some chemical substances in jute may inhibit germination of specific species	Jacoby (1969)
Straw plus plastic netting	Similar to straw, but increased erosion control	Netting is expensive	
Wood residues, sawdust, wood chips, bark	Abundant, adds organic matter, easy to apply, long-lasting	Competition for available N, decreases pH if material fermented, packing of fine particles	Springfield (1971) Bollen (1969) Meyer et al. (1972)
Excelsior	Doesn't require anchoring, good soil protection	Expensive, laborious to apply, attracts mice	Thompson and Palmertree (1967) Cook et al. (1970)
Wood fiber (Hydromulch)	Good moisture retention	Minimum erosion control in areas where frost heaving or excessive water flow occurs	Cook et al. (1970) Bartee (1964)
Petroleum products (asphalt emulsion)	Reduces evaporation, prevents soil crusting, remains intact 4-10 weeks	Repels water and insufficient water available to seeds, less effective in high intensity storm, absorbs high heat loads, test results generally poor	Chepil et al. (1963) Bement et al. (1961) Cook et al. (1970)
Latex emulsions		May limit water infiltration, expensive, poor erosion control	Chepil et al. (1963) Beard (1966)
Plastic films	Reduces evaporation and improves temperature regime	Expensive, doesn't justify advantages	Smith et al. (1967) Herbel (1971)
Gravel, stones	Permanent, reduces erosion, reduces evaporation, increases infiltration of water	May retard seed germination	Chepil et al. (1963) Corey and Kemper (1968) Cook et al. (1970) Meyer et al. (1972)
Macerated paper	Satisfactory moisture retention	Not as long-lasting as straw or wood-fiber	Cook et al. (1970)

5. Fertilizers - Soil surveys and chemical analyses of the soils on Tract C-a indicate that most macro- and micronutrients occur in concentrations adequate to support normal plant growth. Exceptions include nitrogen and phosphorus which average 10 to 13 ppm (RBOSP Progress Report 9, 1977). Since the availability of these two macronutrients is important, particularly during early stages of revegetation, a minimum of 30 pounds/acre of elemental nitrogen and phosphorus will be applied to the surface soils of the disposal areas prior to seeding. Stockpiled soils will be tested prior to placement on the disposal piles to determine any variances from the projected 30 pounds/acre rate. Fertilizer rates will not exceed 60 to 80 pounds/acre (Cook et al., 1974), since such high rates may create conditions advantageous to less desirable species.

It is expected that no additional organic additives will be required in areas where surface soils will be replaced. In surface disturbed areas where soil stockpiling is not practical (e.g., around buildings), subsurface soils will be revegetated directly. In these areas straw will provide additional organic material.

Mycorrhizae, existing naturally in surface soils, enhance shrub and forb establishment and growth. Since surface soils will be placed on the disposal piles, use of soil inoculates e.g., mycorrhizae is not currently planned. Because surface soils will be stockpiled indefinitely and the effect of soil storage on mycorrhizae viability is unknown, potential use of soil inoculates will be periodically reviewed as technology is developed.

6. Irrigation - Annual precipitation in the vicinity of Tract C-a varies from approximately 10 to 17 inches (RBOSP Final Environmental Baseline Report, 1977) with higher amounts at higher elevations. About one-half the precipitation occurs as snow. The preliminary results of the RBOSP revegetation experiments and studies conducted by Sims and Redente (1974) have demonstrated that certain species in the vicinity can be successfully reseeded without supplemental irrigation or fertilizer. Since wide fluctuations in precipitation are common in arid

regions, revegetation plans cannot depend on average rates of rainfall for initial plant establishment, and therefore supplemental irrigation will be applied during extremely dry years. Use of irrigation will be minimal since irrigation could create an abnormally productive community which would tend to concentrate livestock and wildlife.

Sprinkler systems will be used as necessary when drought conditions could jeopardize plant germination and establishment. Irrigation water will be obtained from development activities on site. The water quality of the aquifers underlying the tract is marginal for germination and establishment of most plant species (specific conductance, umhos/cm) upper aquifer range: 810 to 4,200, average = 1,267; lower aquifer range: 845 to 5,180, average = 1,459) (RBOSP Final Environmental Report, 1977). Use of this water for irrigation must be minimized since the levels of hazardous trace elements (e.g., selenium, lead) are above recommended levels (FWPCA, 1968).

7. Biotic Influences and Interactions - Fencing may be required in the disposal areas since the availability of palatable plant species may attract large herbivores (primarily feral horses and domestic livestock); however, such fencing is not planned at this time. The fencing of small areas along roads and around buildings is not feasible. Since the processed shale pile will be revegetated in segments, the size of the areas to be revegetated should minimize the concentrations of herbivores so that additional control programs are not necessary.

8. Management - Seeded areas will be evaluated after the initial revegetation efforts. Additional fertilizer and irrigation may be necessary in the second year of establishment. Prompt revegetation in disturbed areas and proper management should eliminate the need to control undesirable plants with herbicides. Any weed control before planting will be done by mechanical methods such as tillage. Judicious use of selected herbicides may be beneficial in controlling weeds after establishment of vegetation. Revegetated areas will be monitored to determine the success of the revegetation program (see Section 8, Chapter 7).

9. Summary and Conclusion - Much work has been done on revegetation in the arid West and in recent years investigators have studied the potential application of this work on the western slope. Extensive studies have been conducted in western Colorado to determine the most effective means of directly revegetating processed shale. Since RBOSP plans to construct an artificial soil profile on the processed shale disposal pile, the recent studies of directly revegetating shale are not applicable to the revegetation program for Tract C-a. The processed shale and raw shale ore disposal piles represent the most difficult revegetation task for RBOSP because of the extent of disturbance resulting from disposal of processed shale and raw shale ore and the limited information available concerning the potential of the artificial soil profile to eliminate adverse effects of processed shale.

The work by Sims and Redente (1974) which tested the adaptability of numerous plant species to conditions present in the Piceance Creek basin is appropriate to the RBOSP revegetation program. This work investigated the response of plant species sown in pure stands without supplemental irrigation, mulch, or fertilizer. The effects of competition which occur when a composite mixture of grass, forb, and shrub species is sown is known only for the preliminary results of the RBOSP revegetation program. Although available technology seems sufficient to insure successful revegetation , RBOSP has initiated an experimental revegetation program to investigate problems specific to revegetating the disposal piles planned for Tract C-a. This program will also gather additional data concerning those aspects of revegetation methodology which have not been studied in detail under conditions existing in the Piceance Creek basin. RBOSP is confident that they can and will fulfill all lease and state requirements and provide for successful reclamation of all disturbed lands associated with the development of Tract C-a.

C. RBOSP Experimental Revegetation Program - In 1975, RBOSP initiated a three year experimental revegetation program which will evaluate those aspects of technology that are directly applicable to the reclamation planned for Tract C-a. The program includes three successive plantings

(1975, 1976, and 1977). The first two trials were initiated in the fall of 1975 and 1976. The schedule for the RBOSP studies is presented in Table 6-8-4.

The locations of the first year experiments (Site R_1 and R_2) and the second year experiments (Site R_3) are presented in Figure 6-8-2. All three sites are located in the southeast corner of the tract (T2S, R99N, Section 10) along Wolf Ridge, between elevations of 7,100 and 7,200 feet. Wolf Ridge is adjacent to Rinky Dink Gulch which is the planned disposal site for the processed shale during commercial operations. Sites R_1 and R_2 are located on opposite slopes (north and south) and R_3 is located on the south slope to further investigate the slope having the more extreme drought conditions.

1. Revegetation Experiments Initiated in 1975

a. Objectives - Revegetation experiments initiated in 1975 were designed to determine:

- Which species, when sown in a composite mixture, are best adapted to the physical and environmental conditions existing on the tract
- The effectiveness of several mulches in aiding establishment of the sown plant species and in reducing erosion.
- The effects of fertilizer applied at different time periods on the sown plant species.
- The effect of aspect on the establishment of the sown species.

b. Methods - Native vegetation was scraped from each experimental plot site (R_1 and R_2) prior to substrate mixing. Topsoil (about the upper 6 inches of the soil) and the remaining subsoil were stockpiled separately. The underlying bedrock, consisting mostly of fractured calcareous sandstone, was broken to a minimum thickness of 24 inches. Subsoil and topsoil were replaced and graded for sowing.

Table 6-8-4

SCHEDULE OF FIELD EVENTS FOR REVEGETATION STUDIES ON OIL SHALE TRACT C-a
RIO BLANCO COUNTY, COLORADO, 1975 THROUGH 1978

	1975						1976										1977										1978									
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Site Selection	Δ																																									
Field Work																																									
Seedbed Preparation			Δ												Δ												Δ														
Planting			Δ												Δ												Δ														
Measurements of Plant Response to Treatments											Δ		Δ										Δ		Δ										Δ		Δ				
Soil Analyses																																									
Sample Collection			Δ												Δ												Δ														
Moisture Determinations				Δ							Δ		Δ		Δ								Δ		Δ		Δ								Δ		Δ		Δ		
Salinity Determinations															Δ												Δ												Δ		

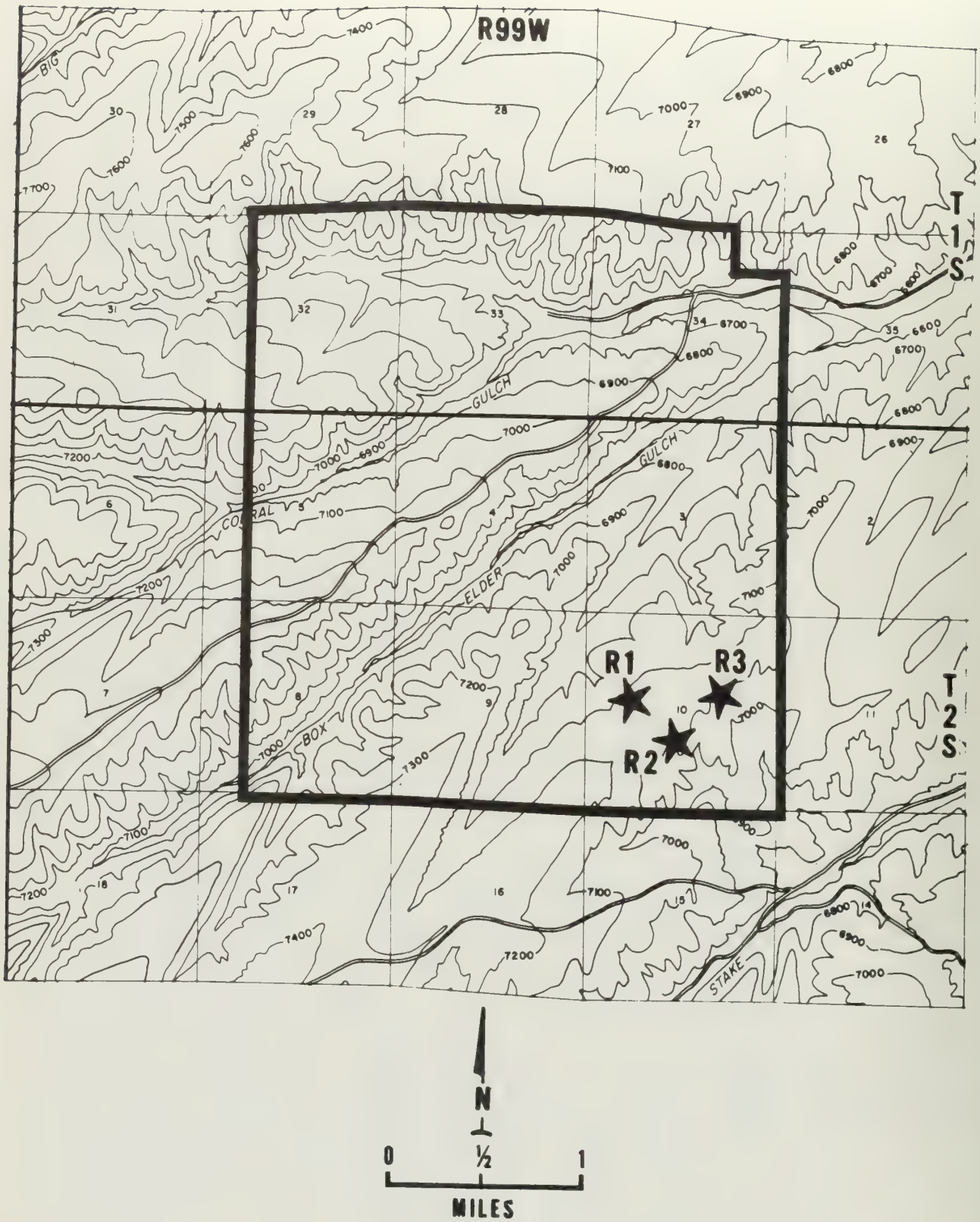


Figure 6-8-2
LOCATIONS OF REVEGETATION TEST PLOTS (R_1, R_2, and R_3)

At R_1 and R_2, each of 16 treatments was applied at random to a 10 x 10 m plot and replicated in three complete blocks (Figure 6-8-3). Each plot was surrounded by a 3 m buffer zone. The total dimensions of the site are 55 x 165 m or 9,075 m^2 (0.91 ha or 2.24 acre per site). The site preparation process disturbed a perimeter around each site, bringing the total area of disturbance per site to 1.7 ha (4.3 acre) or 3.5 ha (8.6 acre) for two sites (R_1 and R_2) (Figure 6-8-3). Within each 10 x 10 m plot, four 1 x 1 m (3.3 feet x 3.3 feet) subplots were randomly established and permanently marked for subsequent data collection.

A composite mixture of grasses, forbs, and woody plants (Table 6-8-5) was drilled with a conventional grassland drill equipped with depth bands and a single-seed box and agitator. This drill placed the seeds in rows 5 to 7 inches apart. Approximately 11 pounds of PLS/acre of grasses and non-grasses (forbs and woody plants) were sown in approximately equal proportions (Table 6-8-5).

For the 1975 test, a total of 16 treatments was applied with all possible combinations of the following variables:

Mulch Type and Application

- No mulch.
- Hydromulch with wood fiber.
- Straw mulch followed by crimping.
- Straw mulch with netting.

Fertilizer Application (10-5-5 applied at a rate of 160 pounds/acre)

- No fertilizer.
- Fertilizer at time of sowing (fall).
- Fertilizer at the beginning of first full growing season (spring).
- Fertilizer at time of sowing and at the beginning of first full growing season.

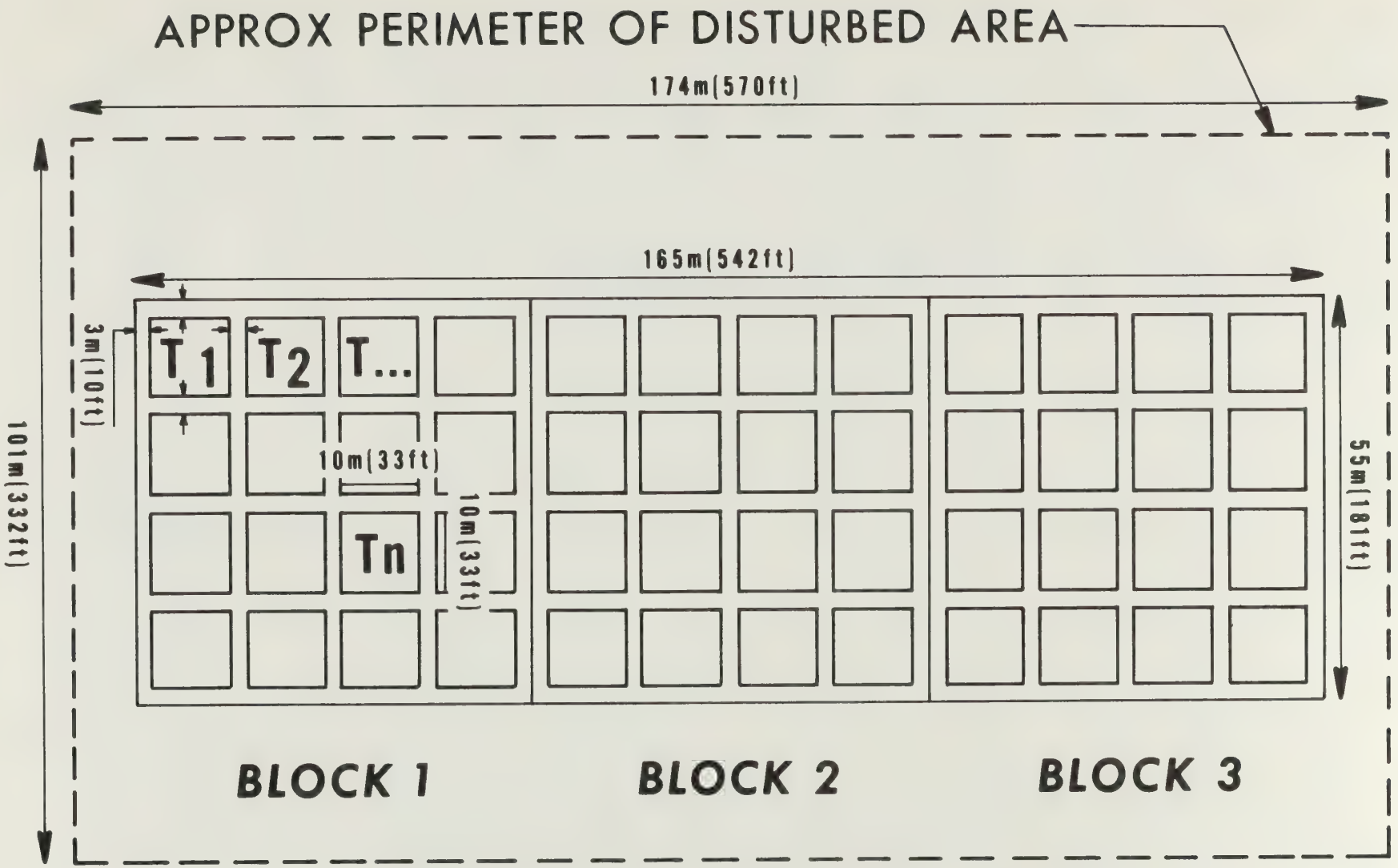


Figure 6-8-3

GENERALIZED PLOT LAYOUT FOR REVEGETATION PLOTS (R_1 & R_2) ON OIL SHALE LEASE TRACT C-a, RIO BLANCO COUNTY, COLORADO, 1975 - 1978. SIXTEEN TREATMENTS (T1-T16) ARE REPLICATED IN THREE COMPLETE BLOCKS. BLOCKS AND TREATMENT PLOTS ARE RANDOMLY LOCATED.

Table 6-8-5

PLANT SPECIES SUITABILITY AND RECOMMENDED SOWING RATES (LBS PLS/ACRE) FOR SPECIES UTILIZED IN REVEGETATION EXPERIMENTS ON OIL SHALE TRACT C-a, RIO BLANCO COUNTY, COLORADO

Species	Suitability Rating[a]	1975 Seeding Rates (lbs PLS/ac)	1976 Seeding Rates (lbs PLS/ac)
Grasses			
Luna pubescent wheatgrass (Agropyron trichophorum var. Luna)	2,4,6,8,9	1.1	1.8
Rosana western wheatgrass (Agropyron smithii var. Rosana)	4,5,8,9	1.3	1.9
Sodar streambank wheatgrass (Agropyron riparium var. Sodar)	3,5,8,9	1.4	1.3
Indian ricegrass (Oryzopsis hymenoides)	2,4,5,7,9	0.5	.4
C-43 Basin wild rye (Elymus cinereus var. C-43)	2,4,5,7,11	0.9	
Green needlegrass (Stipa viridula)	2,5,7	1.3	1.3
Manchar brome (Bromus inermis)	1.6,8		1.3
Forbs			
Lewis flax (Linum lewisii)	2,5	.4	.8
Lutana cicer milkvetch (Astragalus cicer var. Lutana)	6,11	.1	.7
Utah sweetvetch (Hedysarum utahensis)	2,5	.2	.3
Madrid yellow sweetclover (Melilotus officinalis var. Madrid)	2,4,5,9,11	.4	.6
Rocky Mountain penstemon (Penstemon strictus var. bandera)	3,5,9	.4	.4
Scarlet globemallow (Sphaeralcea coccinea)	3,5,9	.2	
Common daisy (Chrysanthemum leucanthemum)	3,5,9		.3
Big sagebrush (Artemisia tridentata)	2,5,9,10,11	.1	
Little rabbitbrush (Chrysothamnus viscidiflorus)	2,4,5,9,11	.1	
Bitterbrush (Purshia tridentata)	1,5,9,10,11	.5	.8
Mountain mahogany (Cercocarpus montanus)	1,5,10	.3	.8
Fourwing saltbush (Artiplex canescens)	1 (seeds), 3,4,5,9	.5	.7
Winterfat (Eurotia lanata)	1,5,10	.3	.4
Rubber rabbitbrush (Chrysothamnus nauseosus)	3,5,9,10,11	.3	.4
Squaw bush (Rhus trilobata)	2,4,5,9,10,11	.2	
Serviceberry (Amelanchier alnifolia)	2,5,10,11		.6
Trees			
Utah juniper (Juniperus osteosperma)	3,5,9,10,11	0.1	
Pinyon pine (Pinus edulis)	3,5,9,11	0.1	.2
	TOTAL	10.7	15.0

[a] Suitability ratings are:

1 highly palatable	7 bunch grass
2 moderately palatable	8 sod grass
3 unpalatable	9 drought resistant
4 soil stabilizer	10 browse
5 native to Colorado[b]	11 cover for game
6 introduced species	

[b] Underlining indicates species observed on site as part of the environmental baseline studies.

Additional information concerning the details of the methodology used for these experiments is available in the RBOSP Progress Report 4 Summary (1975).

c. Results - Data on emergence density, survival density, and percent cover were collected during the first growing season (1976) for the revegetation experiments initiated in 1975. Additional measurements of cover and measurements of above-ground biomass will be collected, as outlined in Table 6-8-6.

Results of an analysis of variance on emergence, survival, and cover data indicated that significant differences occurred among species and among treatments. The first year density data indicated significant differences among mulch treatments. Generally, the straw mulches had better seedling establishment and survival than the no mulch or hydromulch treatments. The results of the effect of fertilizer application at different time periods were less conclusive. Further measurements of percent cover and biomass should provide more valid tests of the effects of fertilizer.

Of particular interest was the success obtained by seeding shrubs directly. Winterfat, rabbitbrush, and saltbush and, to a lesser extent, bitterbrush and mountain mahogany were common species on both the north and south sites. Winterfat set seed during the first growing season and rabbitbrush and saltbush frequently obtained heights of 12 to 14 inches. These results indicated that wildlife habitat similar to that presently existing on Tract C-a can be reestablished.

Additional information concerning the results of the first year of the 1975 experiments is presented in the RBOSP Progress Report 9 (1977).

2. Revegetation Experiments Initiated in 1976

a. Objectives - Revegetation experiments initiated in 1976 are designed to determine:

Table 6-8-6

PLANT RESPONSE PARAMETERS MEASURED IN REVEGETATION EXPERIMENTS ON OIL SHALE TRACT C-a, RIO BLANCO COUNTY, COLORADO, 1976 - 1978

Parameter	Time of Measurement	Taxa Involved
Number of emerged seedlings per plot	first spring following fall planting, i.e., beginning of first growing season	each planted species
Number of surviving seedlings	end of first growing season	each planted species
Above-ground biomass (dry wt.)	end of third growing season	total seeded species, total alien species, individual seeded species contributing bulk of biomass
Percent cover	end of each growing season	each species

- If the simulated artificial soil profile can inhibit upward capillary migration of salts from TOSCO II processed shale.
- Which plant species (sown in a composite mixture on the simulated artificial soil profile) are best adapted to the environmental conditions existing on a south exposure on Tract C-a.
- Which mulches when applied to the simulated artificial soil profile are effective in aiding establishment and survival of plant species and in reducing erosion.
- Growth and survival of native shrubs that are sown directly or planted as tubelings on the simulated artificial soil profile.

b. Methods - The 1976 revegetation experiments were designed to simulate the artificial soil profile for the processed shale disposal pile as described earlier.

The soil profile was prepared by separately stockpiling topsoil (6 inches) subsoil (12 inches), and excavated sandstone (12 inches). An additional 36 inches of rock and soil material was excavated from the revegetation site and stockpiled. A plastic sheet was placed into a prepared area 5.5 feet deep to insure that no contamination of ground water could occur and to facilitate collection of any leachate for analysis. Perforated plastic pipe was placed in three locations for collection of leachate: 1) at the top of the compacted shale, 2) beneath the compacted shale, and 3) beneath the sandstone material on the control side of the experimental plot. Due to the limited availability of TOSCO II processed shale, 20 inches of processed shale was placed on top of the plastic sheet. The processed shale was compacted to prevent penetration or leaching and to simulate the 5 foot surface layer of the compacted processed shale of the proposed disposal pile configuration. The control plot was underlain by approximately 20 inches of sandstone which had been excavated from the revegetation site and which had previously been stockpiled. After the processed shale was compacted, 3 feet of overburden (12 x 0 inch size) was bulldozed over the processed shale and the excavated sandstone of the control plot. The topsoil and subsoil were replaced in proper sequence.

The 1976 revegetation site used a 53 x 53 m (174 x 174 feet) area (0.3 ha or 0.70 acre) (Figure 6-8-4). An approximate 23 m (75 feet) wide boundary area surrounding the revegetation site was disturbed by operation of machinery, removal and stockpiling of vegetation, and temporary stockpiling of soil material. Thus a total of 1.0 ha (2.41 acres) was disturbed by the 1976 experiments.

At the site, each 6 x 6 m plot received one treatment and the six treatments (3 mulch and 2 shale-no shale conditions) were applied six times to a total of 36 plots (Figure 6-8-4). Each plot is surrounded by a 1 m buffer zone, except that a 5 to 6 m buffer zone exists along the outermost perimeter of the treatment plots to reduce microclimatic effects and a 3 m buffer occurs in the center of the plot at the interface of the processed shale and control area. Within each 6 x 6 m treatment plot, a minimum of three 1.0 x 0.5 m subplots will be randomly established and permanently marked for subsequent data collection.

Grass, forb, and shrub seed was sown as a composite mixture (Table 6-8-5) after the simulated artificial soil profile had been prepared. For the 1976 test, 15.0 pounds PLS/acre were sown, with non-grasses (forbs and woody plants) in slight excess of the grasses (Table 6-8-5). Seed was drilled using a conventional grassland drill equipped with depth bands and a single-seed box and agitator. Rice hulls were added to the seed mixture as a "filler substance" to increase the bulk of seed in the seed box. Depth bands insured that seed was not drilled deeper than 2 cm (0.5 to 0.75 inches). Drilling resulted in a spacing of 5 to 7 inches between planting rows.

Direct seeding of a composite seeding mixture will be compared to plantings of tubelings, a popular type of containerized seedling. Tubelings are being grown by the USDA Shrub Science Laboratory from the same seed lots that were used for direct seeding. Five shrub species (excluding Amelanchier alnifolia) and pinyon pine will be utilized for the tubeling treatment. Tubeling size will be 18 cubic inches (2 inches x 1.5 inches x 6 inches). The tubelings will be planted by hand in each treatment plot in early or

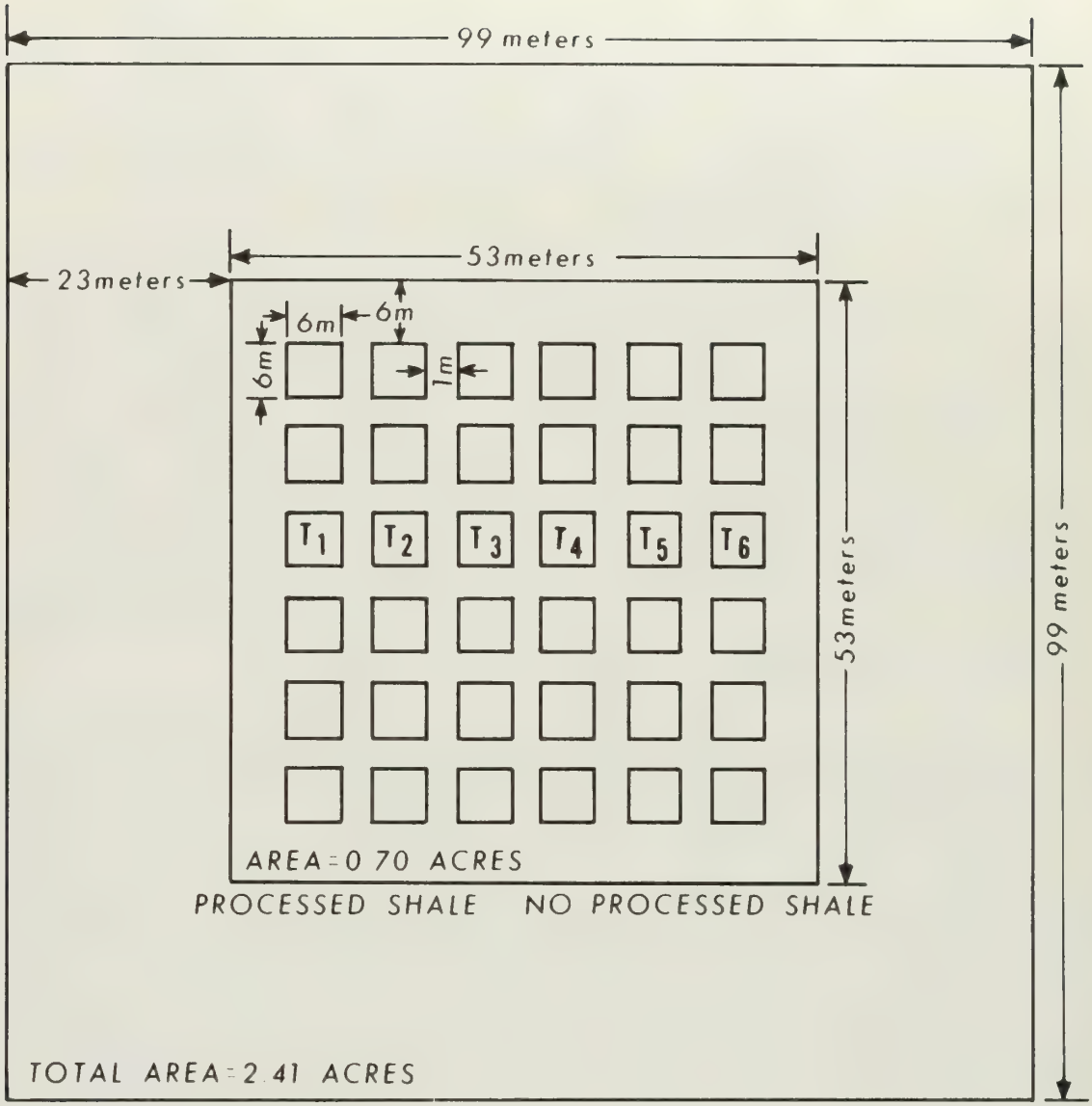


Figure 6-8-4

GENERALIZED PLOT LAYOUT FOR REVEGETATION PLOT (R_3) ON OIL SHALE TRACT C-a, RIO BLANCO COUNTY, COLORADO (INITIATED IN 1976). SIX TREATMENTS (T1-T-6) HAVE BEEN APPLIED TO SIX REPLICATES.

mid-June at a rate of 18 tubelings/plot (1800 tubelings/acre); three tubelings of each of the six species will be used.

For the 1976 tests, six treatments consisting of all possible combinations of the following variables were applied:

Simulated Artificial Soil Profile

- Simulated artificial soil profile underlain by excavated sandstone ("control").
- Simulated artificial soil profile underlain by TOSCO II processed shale.

Mulch Type and Application

- No mulch.
- Hydromulch with wood fiber (0.75 tons/acre).
- Native hay followed by crimping (2 tons/acre).

The following plant response parameters will be measured for each treatment: 1) number of emerged seedlings per plot, 2) number of surviving seedlings per plot, and 3) percent cover. Table 6-8-6 gives the season of measurement for each parameter and the taxa involved. Additional information concerning the experiments initiated in 1976 are presented in the RBOSP Progress Report 9 (1977).

3. Summary and Conclusion - The revegetation experiments outlined above constitute the present plan for revegetation. Results of these tests should further refine the selection of specific seed mixtures for different site conditions and of the most effective mulches, fertilizer schedule, and shrub establishment techniques. In addition, the trials will indicate how well vegetation can be established and maintained without supplemental irrigation. Most important, the use of TOSCO II processed shale in the experiments initiated in 1976 will test the feasibility of using a crushed rock layer to reduce upward migration of salt into the plant rooting zone. Although only one substrate configuration

is presently being tested, this does not preclude the possibility that additional substrates will be tested if new developments and technology so warrant.

As this 3-year study progresses, the results will be reviewed in consultation with the AOSO to determine the extent of additional studies.

CHAPTER 9

SOLID WASTE CONTROL

CHAPTER 9
SOLID WASTE CONTROL

The Solid Waste Control Plan describes the expected disposal methods for solid wastes, excluding processed shale and development ore (see Section 4), which are produced during the construction and operation phases of the project. These solid wastes include process (water and gas treatment wastes and catalysts) and nonprocess (paper, wood, metal, etc.) related waste.

The primary regulations relating to solid waste disposal in Colorado are contained in Chapter 36, Article 23, Colorado Revised Statutes, 1963, as amended. The Colorado Department of Health is charged with administering these regulations. RBOSP will comply with the above law and in addition to all applicable Federal and local laws, rules and regulations.

9.1 NONPROCESS WASTES

A. Composition and Quantity - During construction and operation of the project, nonrecyclable wastes will be produced in the mine, processing facility and processed shale and development ore disposal areas. The estimated composition of this waste during the operational phases is as follows:

Material	Weight Percent
Paper	28
Organic Waste	7
Glass	8
Nonrecyclable metals	14
Wood	7
Plastics	8
Rubber and leather	14
Textiles	4
Laboratory waste	8
Miscellaneous inorganics	2
Total	100

Wood and nonrecyclable metals are expected to represent much higher percentages of the total waste during construction. A rough estimate of the quantity of waste generated by the project has been made based on manpower projections. Estimates for the Modular Development Phase (MDP) are two (2) tons per day of solid waste. The Commercial Phase estimates are nine (9) and five (5) tons per day of solid waste for construction and operation, respectively.

B. Collection and Transport - Nonrecyclable waste will be collected in covered steel containers placed conveniently around the project area. The capacity of the containers will vary from 1 to 5 cubic yards depending on the nature and volume of waste. A collection-compactor truck will collect the waste on a regular schedule and transport it to a sanitary landfill.

Separate containers, suitably marked, will be provided for recyclable materials. Vendors will probably call at the project to collect some recyclable material. That material not collected by vendors will be transported to recycle centers by available project transportation.

C. Disposal - All solid waste that is not recycled will be disposed of in an approved sanitary landfill. During the MDP, waste will be hauled to existing approved sanitary landfills. Once commercial operation is underway, the landfill will be located in the processed shale disposal site. RBOSP will prepare the "Engineering Data" required by Colorado Department of Health regulations and apply to the Rio Blanco County Board of Commissioners for a Certificate of Designation to operate a solid-waste disposal site. The detailed engineering will be accomplished during the final design of the project so that the disposal site can be placed in operation when commercial operation of the facility begins.

The excavated trench method will be employed to facilitate compaction and cover, together with temporary fencing to minimize scattering of paper and trash by wind. Present planning contemplates that solid-

waste disposal will be at the processed shale disposal site. The solid waste disposal trenches will be constructed within the compacted processed shale. This expedient will minimize the land disturbed for the actual disposal, eliminate the need for construction and maintenance of separate access roads and storm diversion facilities, and require less equipment, fuel and manpower.

9.2 PROCESS WASTES

A. Modular Development Phase - The principal solid wastes produced in the MDP are small amounts of lime sludge and spent zeolite water softening resins from the water treatment system and sludge from the flue gas scrubber. Table 6-9-1 lists the estimated quantities of solid wastes.

Table 6-9-1

MODULAR DEVELOPMENT PHASE PROCESSING SOLID WASTES

Process Unit	Solid Waste Description	Approximate Quantity TPY
Water Treatment	Spent zeolites	0.3
	Lime sludge (water-free solids)	70
Flue Gas Scrubber	Sludge Solids	30,000

The water treatment lime sludge is mostly $CaCO_3$ with some $Mg(OH)_2$ and SiO_2. The flue gas scrubber sludge is mostly $CaSO_3$ and $CaSO_4$. The sludges and spent zeolites will be disposed of in an approved sanitary landfill.

B. Commercial Phase - The Commercial Phase processing facility will generate a certain amount of spent catalysts from the sulfur plants and wastes from water treating. Table 6-9-2 lists the expected solid wastes and estimated quantities.

Table 6-9-2

COMMERCIAL PHASE PROCESSING FACILITY SOLID WASTES

Process Unit	Solid Waste Description	Approximate Quantity* TPY
Sulfur Recovery		
Claus Unit	Spent oxidation catalyst	45
Tail Gas Unit	Spent hydrogenation catalyst	8
Water Treating	Spent zeolites	3
	Lime sludge	870

*Average over catalyst life

The spent zeolites and lime sludge will be disposed of with the processed shale in the processed shale disposal piles. The spent catalysts, which will not contain arsenic, will be recycled to the manufacturer.

CHAPTER 10

AESTHETICS

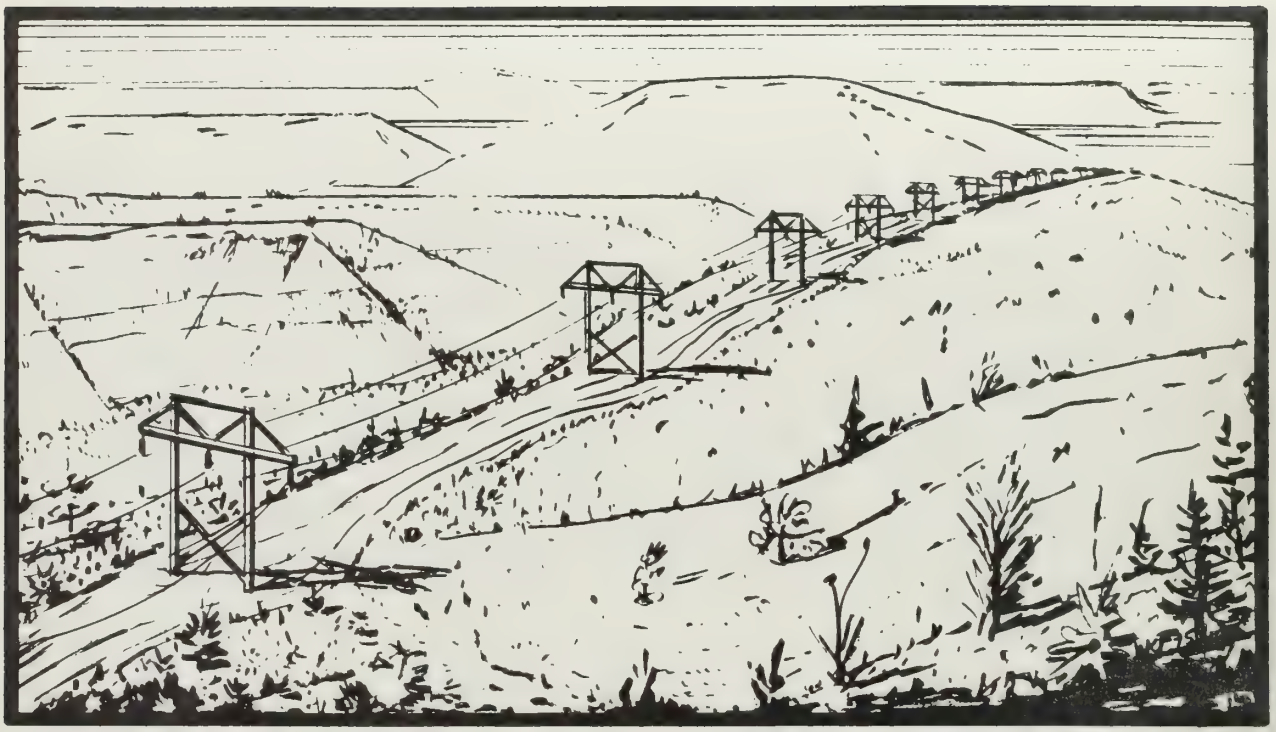
CHAPTER 10
AESTHETICS

The principal aesthetic value of Tract C-a and its environs is the landscape, which is characterized by rolling hills with flat-topped ridges and rounded canyon walls dropping steeply 100 to 300 feet into narrow, flat-bottomed valleys. Aesthetic values were considered in planning all facilities and operations. However, aesthetic guidelines could not always prevail because of economic constraints and conflicting environmental requirements. Criteria used to minimize the visual impact of the project and preserve scenic values are discussed in the following paragraphs.

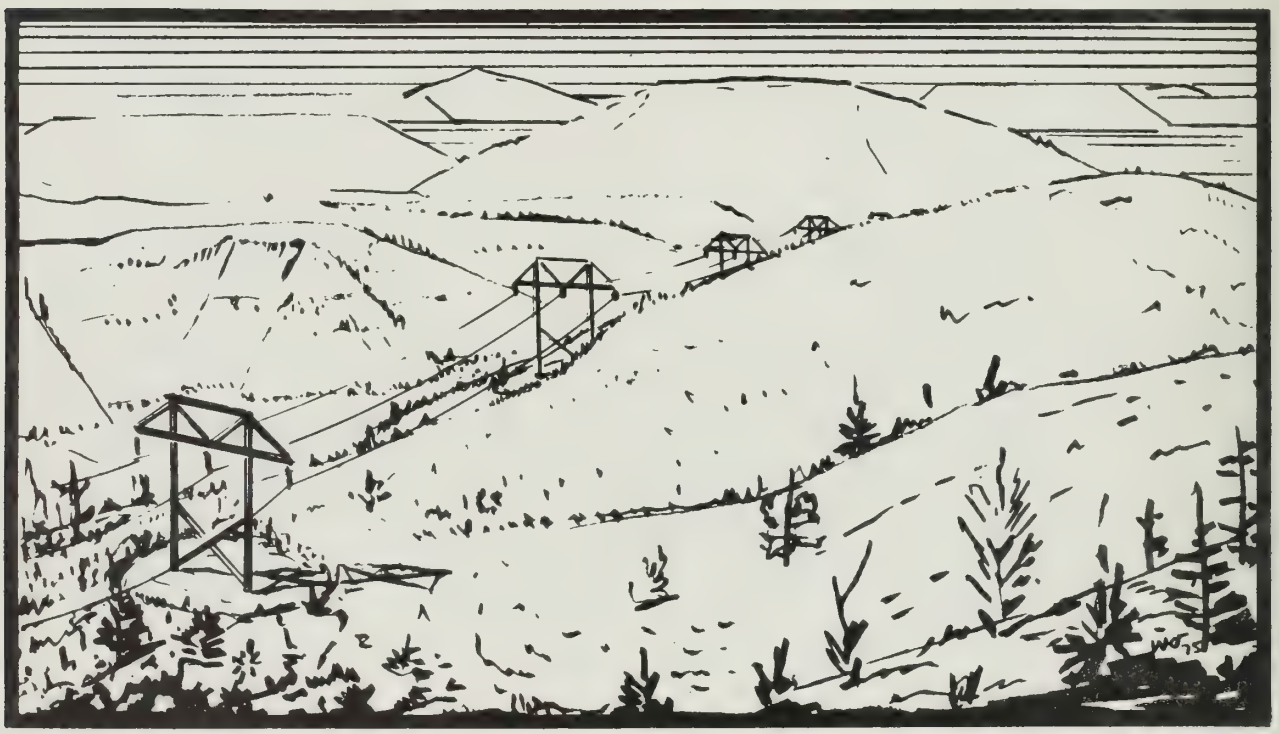
10.1 LOCATION

The visual impact of engineering features is greatly affected by their location and surroundings. The following concepts will be applied in minimizing this impact:

- Make outlines as nearly parallel to natural ground lines as possible.
- Locate transmission lines and pipelines so that extensive clearing will not be required.
- Locate transmission lines so that they will cross ridges in natural depressions, when possible (see Figure 6-10-1).
- Locate pipelines to avoid sidehill cuts.
- Minimize land disturbance through the multiple-use corridor concept.



POOR LOCATION AND EXCESS CLEARING



GOOD LOCATION WITH MINIMUM STRIPPING

Figure 6-10-1

POWER LINE ROUTING AND CONSTRUCTION

10.2 MATERIALS AND COLOR

Exposed construction materials will be selected or painted to reduce their visual impact. Bright colors and bare galvanized steel will be avoided where possible. The processed shale pile will be covered with coarse granular material and soil (and, ultimately, vegetation) to blend with the natural background. Development ore disposal piles will also be covered with soil and revegetated to blend with the natural background.

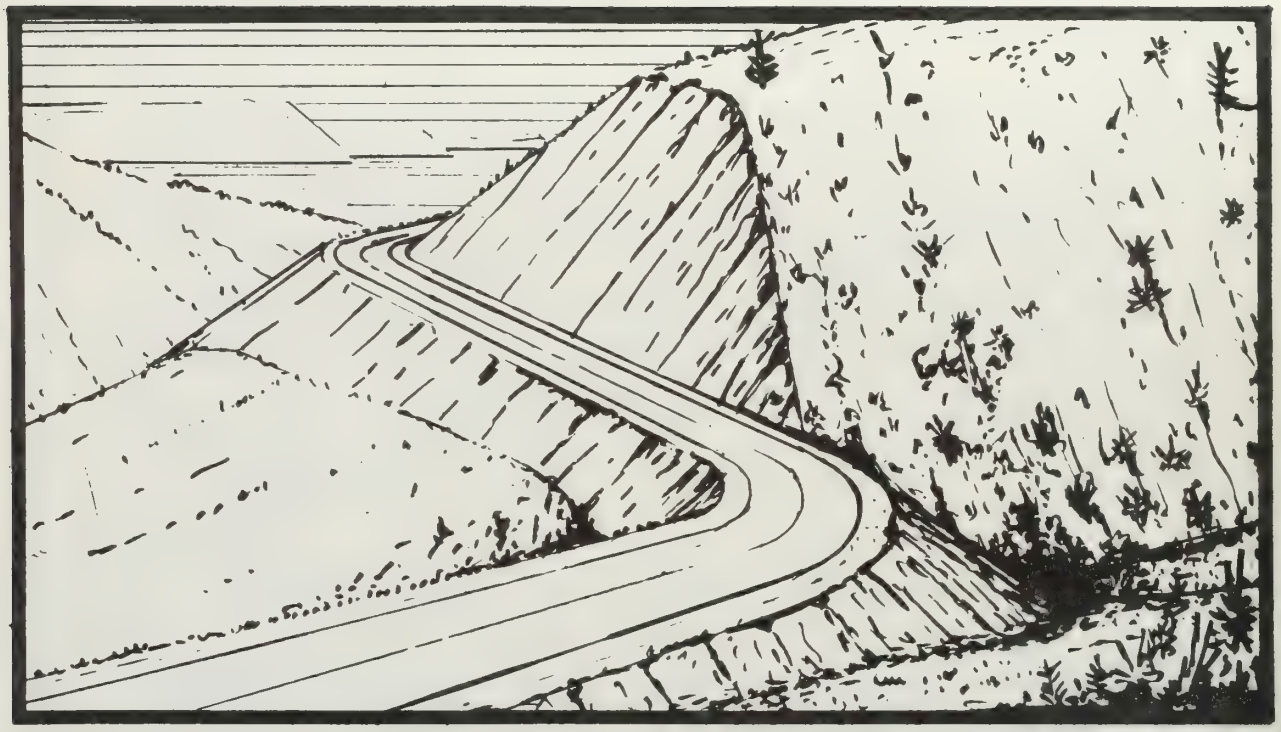
10.3 SHAPE

Major processing structures and buildings have distinctive shapes, and little can be done to alter these shapes without interferring with their operational and economical functioning. However, in earthmoving activities and disposal pile construction, shape will be used as a means of reducing visual impact, as follows:

- Changes from formal to natural lines will be made gradually.
- Slope rounding will be used to blend man-made slopes into the natural ground shape (see Figure 6-10-2).
- Benches and terraces will be used to break up long slopes (see Figure 6-10-3).
- Natural looking ridges and valleys will be constructed in large disposal piles (see Figure 6-10-4).

10.4 VEGETATION

The ultimate success in minimizing visual impact will depend largely on the success of the revegetation program. Contrasting vegetation types will be used to enhance the appearance of the overall project. However, any new vegetation will be chosen to blend with existing vegetation.



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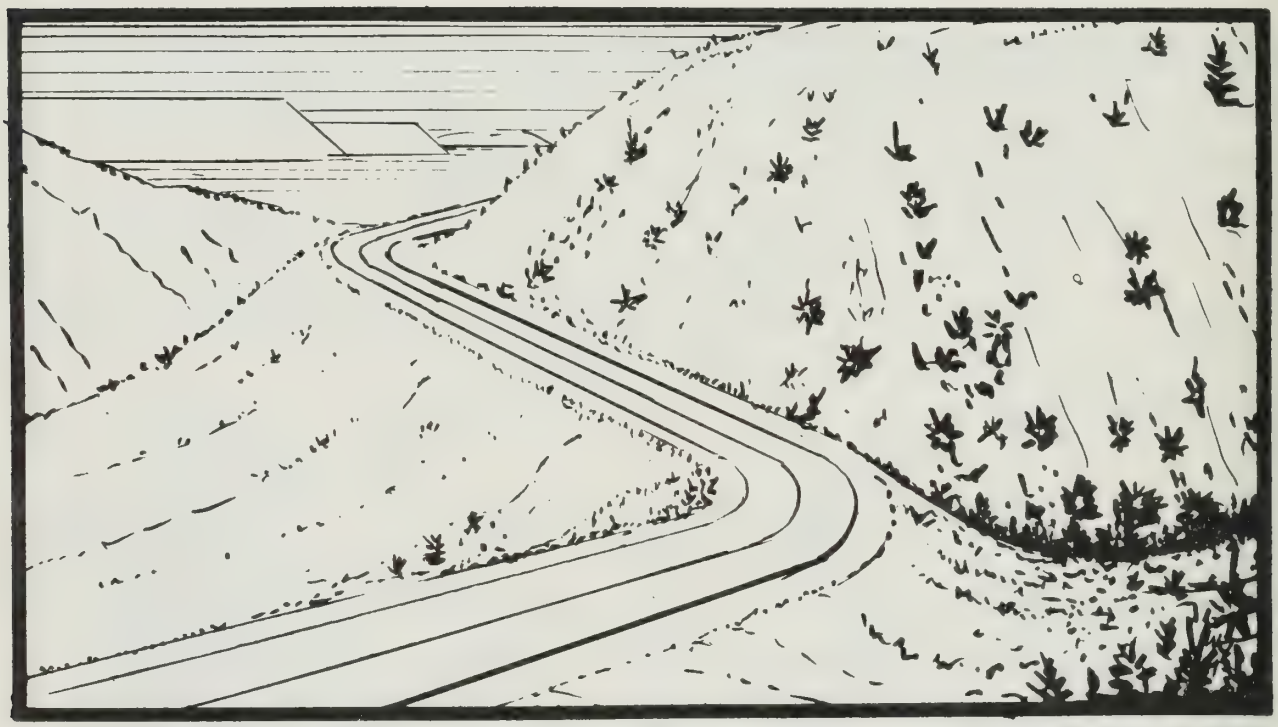
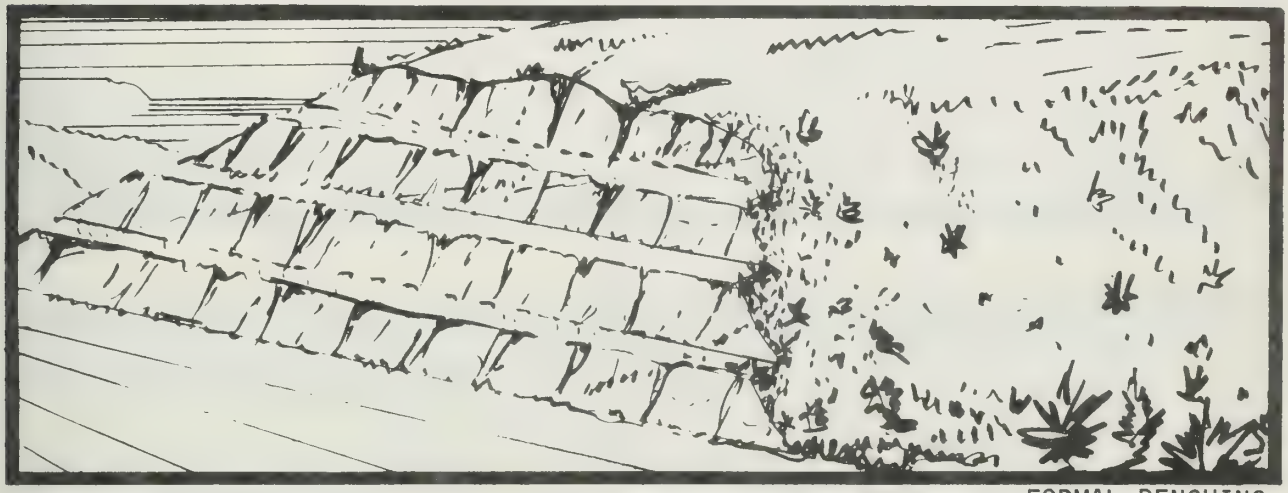


SLOPES ROUNDED AND REVEGETATED

Figure 6-10-2
SLOPE ROUNDING

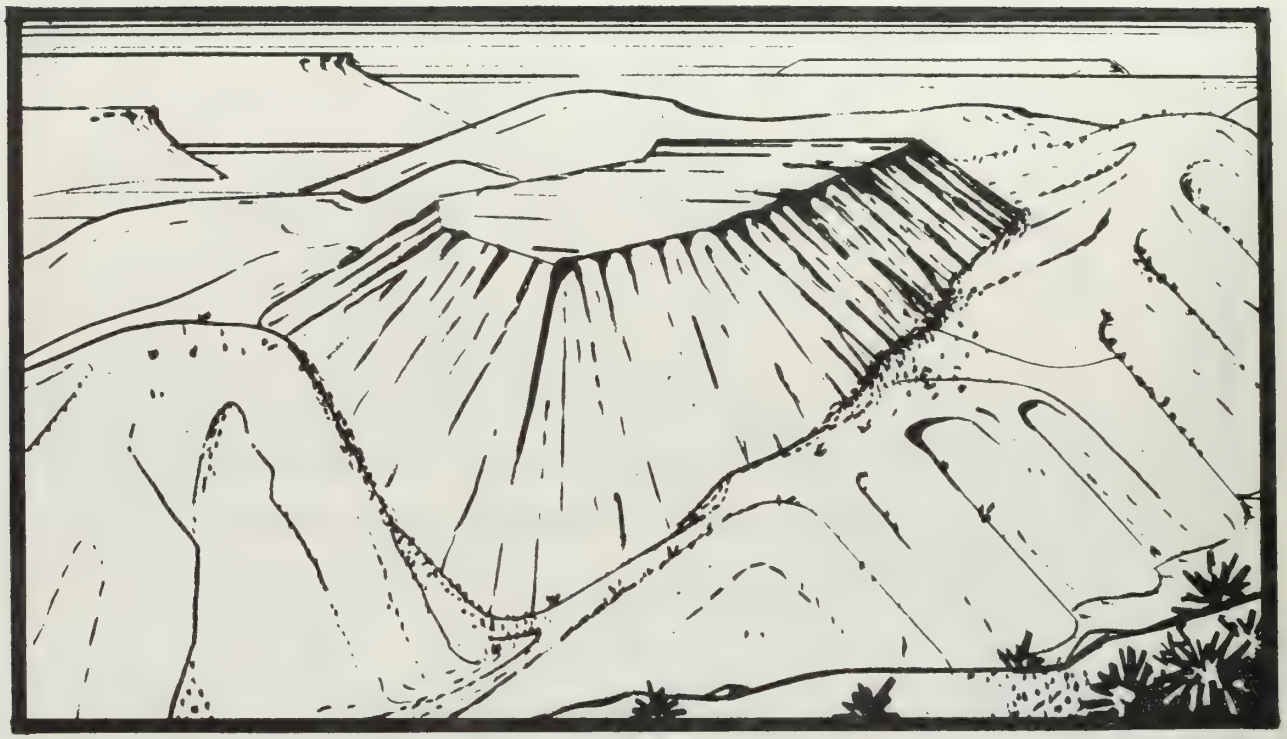
UNTREATED SLOPE



FORMAL BENCHING

INFORMAL BENCHING

Figure 6-10-3
BENCHING AND TERRACING



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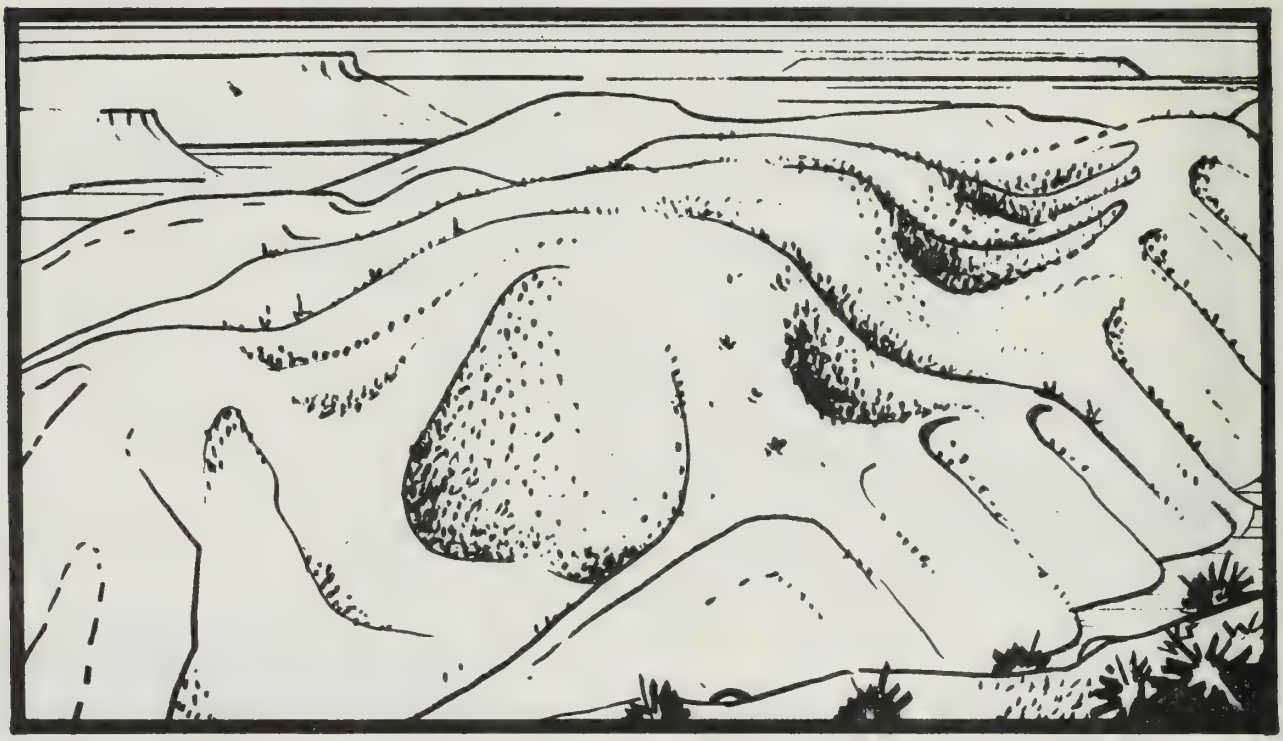

ROUNDED AND REVEGETATED

Figure 6-10-4
DISPOSAL PILE SHAPING

Movements of processed shale and earth will be coordinated with revegetation efforts to aid in the control of sedimentation and erosion and in the restoration of vegetation. Such coordination of efforts will contribute to the development of aesthetically pleasing designs and facilitate operation and maintenance.

Cuts and embankments, properly constructed and revegetated, will soon become part of the landscape, requiring minimal attention and maintenance.

10.5 CLEARING

The cleared right-of-way for electric transmission lines and pipelines will produce, by far, the greatest aesthetic impact. The scar left by a bare area cleared for a right-of-way is difficult to remove. Therefore, such cleared areas will be avoided as much as possible.

In the Tract C-a area, several techniques will be employed to minimize the visual impact. Most of the vegetation consists of types that have limited height. In areas where sagebrush predominates, there is little need to clear a wide straight path for a transmission line.

In areas where pinyon-juniper vegetation exists, the same technique can be used. Transmission lines will be constructed with sufficient clearance between conductor cables and vegetation. Topping or removal of tall trees may be required in local areas.

When clearing a right-of-way, all vegetation possible will be left undisturbed. "Dozed" paths will not be permitted. Only the larger vegetation will be removed.

10.6 SIGNS

Signs will be of rustic appearance and constructed to blend with the natural landscape. However, they will not be camouflaged so that

the public cannot see them and heed their warnings.

Signs on State and County highways will comply with the standards of the respective State of County highway agency. All other road signs will be designed in accordance with Bureau of Land Management Standard No. 9132.

CHAPTER 11

FISH & WILDLIFE MANAGEMENT PLAN

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER 11

FISH AND WILDLIFE MANAGEMENT PLAN

11.1 INTRODUCTION

The development of Tract C-a will cause unavoidable, adverse impacts to the environment. The lease stipulations issued by the United States Department of Interior in February 1974 required RBOSP to avoid, minimize, and/or mitigate damage to fish and wildlife habitat. The Oil Shale Lease, Section 4, Environmental Stipulations requires that RBOSP submit:

> "a detailed fish and wildlife management plan which shall include the steps which the Lessee shall take to: 1) avoid or, where avoidance is impracticable, minimize damage to fish and wildlife habitat, including water supplies; 2) restore such habitat in the event it is unavoidably destroyed or damaged; 3) provide alternate habitats; and 4) provide controlled access to the public for the enjoyment of the wildlife resources on such lands as may be mutually agreed upon. The plan shall include, but not be limited to, detailed information on activities, time schedule, performance standards, proposed accomplishments, and ways and means of avoiding or minimizing environmental impacts on fish and wildlife" (p. A-17).

RBOSP is committed to mitigating, to the extent possible, adverse impacts to fish, wildlife, and their habitat which will result from development activities. RBOSP will cooperate fully, in accordance with the lease agreements with AOSO and appropriate government agencies, to reach these goals. Mitigation efforts will be monitored to assess their effectiveness. Any necessary modifications will be made in cooperation with the AOSO.

Tract C-a is located in western Colorado's Rio Blanco County and encompasses 5,100 acres in the Piceance Creek basin. The tract is drained by Yellow Creek and its tributaries. Yellow Creek flows into the White

River 20 miles north of the tract. An extensive study of the terrestrial and aquatic ecosystems was conducted by RBOSP during the 2 years of baseline environmental studies. Aquatic habitat is limited in the vicinity of Tract C-a; no fish occur on tract. Pinyon-juniper and sagebrush dominate the terrestrial habitats and support a diversity of wildlife. A complete description of the Tract C-a environment is presented in the RBOSP Final Environmental Baseline Report (1977). The Tract C-a environmental setting and wildlife inventory have been summarized in Section 7, Chapter 2.

RBOSP proposes to produce oil from shale by a Modified In Situ (MIS) process. Development plans include oil production by underground as well as by surface retorting. Shale oil production by underground retorts will reduce adverse impacts to the environment; surface retorting will reduce waste of the mined out oil shale resource. A summary of the proposed mining and processing operations is presented in the Project Background and Overview (Section 1, Chapter 1) and a complete engineering description of these operations is included in Sections 2, 3, 4, and 5.

Most environmental impacts of RBOSP oil shale development will be limited to the Tract C-a vicinity. Potential adverse impacts were examined by means of a cause-effect matrix analysis (Leopold et al., 1971). Numbers in the matrix were based on mining plans and ecological data collected during the baseline studies. An assessment of potential environmental impacts of the Modular Development and Commercial Phases of RBOSP oil shale development, and proposed measures to mitigate these impacts, are discussed in detail in Section 7. Detailed ecological monitoring plans are presented in Section 8.

Potential primary impacts from Tract C-a oil shale development will include the following.

- Physical destruction or damage of habitat and wildlife from construction or subsidence.

- Loss of habitat available for wildlife because of fencing or other obstruction.
- Damage to habitat by airborne effluents (gases, dust).
- Wildlife stresses caused by noise.
- Loss of water from mine dewatering.
- Potential contamination of ground and surface waters.

Secondary impacts are more difficult to quantify than direct impacts. Potential secondary impacts resulting from human activity include:

- Increased recreational use.
- Increased road kills.
- Increased human harassment of wildlife in general.

Controls designed to minimize changes in ambient air quality, existing water supplies, and ambient noise levels are detailed in the Environmental Control Plans, Section 6 (Noise Control - Chapter 4; Air Quality Control - Chapter 5; Water Quality Control - Chapter 6; Erosion Control - Chapter 8 and Solid Waste Control - Chapter 9). Impacts of unavoidable disturbances to habitat will be mitigated by the improvement or enhancement of the remaining natural habitat and by the restoration of disturbed areas to habitats at least equal to the habitats lost. Detailed methods for revegetation of disturbed habitats are presented in Section 6, Chapter 8.4.

A schedule of proposed terrestrial habitat disturbance, revegetation, and modification is presented in Table 6-11-1. Plans to mitigate potential surface water losses are presented in Section 7, Chapter 6. No fish occur within the tract, therefore restoration of fisheries habitat is not required. Planned retention ponds and sewage treatment facilities may provide habitat suitable for aquatic biota other than fish. No aquatic habitat restoration or alteration is currently planned.

Approximately 471 acres of terrestrial habitat will be disturbed during the Modular Development Phase (Table 6-11-2). Only 44 acres of this

Table 6-11-1

ACRES OF TERRESTRIAL HABITAT TO BE DISTURBED AND REVEGETATED, OR MODIFIED DURING RBOSP MINING ACTIVITIES PLANNED FOR TRACT C-a

	Acres	1978 - 1982	1983 - 1986	1987 - 1991	1992 - 1996	1997 - 2001	2002 - 2006	2007 - 2011	2012 - 2016
Mine and Plant Site	Disturbed	60	218						
	Modified[1]								
Run of Mine Disposal Area	Disturbed	65							
	Revegetated		65						
Primary Crushed Ore Disposal	Disturbed		260						
	Revegetated		200	60					
Corridors	Disturbed	133	39	104					
	Revegetated	92	53	104					
	Modified								
Processed Shale Disposal Pile	Disturbed		70	320	210	40	240		
	Revegetated				20	215	215	215	215

[1] Represents habitat to be modified as part of the Fish and Wildlife Management Plan.

[2] The acreage and/or date are unknown at this time but habitat disturbance, revegetation or modification will occur during the period indicated.

Table 6-11-2

APPROXIMATE ESTIMATE OF THE EXTENT (ACRES(OF HABITATS DISTURBED AS A RESULT OF RBOSP CONSTRUCTION ACTIVITIES DURING THE MODULAR DEVELOPMENT PHASE AND COMMERCIAL PHASES

Construction Area	Mixed Brush	Pinyon-Juniper	Pinyon-Juniper Mixed Brush	Pinyon-Juniper Sagebrush	Upland Sagebrush	Bottomland Sagebrush	Rabbit Brush	Grease Wood	Shadscale		Total
Modular Development Phase											
Mine & Plant Site	14		2	6	12						34
Run of Mine Disposal Area			14	28	23						65
Primary Crushed Ore Disposal Area	1	23	9	77	150						260
Corridors	28		46	2	17	6			13		112
Totals	43	23	71	113	202	6			13	Subtotal	471
Commercial Phase											
Mine & Plant Site	34	5	46	118	41						244
Processed Shale Disposal Pile	56	4	152	164	403	86			15		880
Corridors	15	2	69	11	8	27	18	5	9		164
Totals	105	11	267	293	452	113	18	5	24	Subtotal	1,288
										Total	1,759

will be destroyed (i.e., removed from terrestrial biota for the duration of mining activities on Tract C-a). About 34 acres will be permanently occupied by the mine and plant site, and 20 acres will be destroyed by the development of transmission line corridors (pole bases, guy wires, etc.). The remaining 427 acres, to be disturbed but not destroyed during the Modular Development Phase, consists of the run of mine disposal area, the primary crushed ore disposal area, and 92 acres of transmission line corridors (Table 6-11-2).

The small amount of permanent habitat loss during the Modular Development Phase (44 acres) should have no significant effects on vegetation or fauna in the RBOSP study area. The vegetation types involved (Table 6-11-2) are relatively common on and near the study area.

Some small animals (e.g., rodents, lagomorphs, songbirds) will be destroyed or forced to leave the habitat and attempt to become established elsewhere. However, even if all the animals inhabiting the 44 acres to be destroyed were lost, no major impact on populations of these species in the area would be likely. The disturbance, but not destruction, of an additional 427 acres during the Modular Development Phase represents a greater potential impact on terrestrial biota. However, since all of this land will be revegetated, no long-term adverse impacts are anticipated.

Specific measures will be implemented by RBOSP to mitigate adverse effects of the Modular Development Phase. Clearing the minimum area absolutely necessary, and making concerted efforts to minimize disturbance to immediately adjacent areas, are an important part of RBOSP's overall planning process. Care will be taken to choose the most environmentally sound clearing and construction methods (at the time development occurs) and to closely supervise the implementation of these methods. Woody material cleared from construction areas will be used to build brush piles in appropriate locations. These brush piles will provide cover for small animals and perches for songbirds. The construction of transmission lines through homogeneous habitat (especially one with dense woody

cover) could increase vegetative diversity in that area. This increased habitat diversity could be beneficial to certain wildlife species (e.g., those that utilize vegetation in early successional stages). Therefore, part of the construction activity itself could be considered mitigative in nature. Wildlife habitat modification techniques are discussed in this plan (11.2). RBOSP will consider an initial plan, during the Modular Development Phase, to evaluate several of these techniques on Tract C-a (e.g., conversion and/or modification of small areas of pinyon-juniper and upland sagebrush to determine the potential value of these manipulations on the tract). Revegetation plans for Tract C-a are summarized in this Chapter (11.2) and described in detail in Section 6, Chapter 8.4. Revegetation of all habitat disturbed, but not destroyed, during the Modular Development Phase will be accomplished within one year following its disturbance.

During the Commercial Phase, an additional 261 acres of terrestrial habitat will be permanently destroyed. The lease stipulates that it will be necessary to modify adjacent habitat to compensate for the destroyed habitat. Approximately 60% of the total area that will be permanently altered is presently pinyon-juniper associations; the remainder is primarily sagebrush and mixed brush (Table 6-11-2). Baseline studies indicate that range conditions of the study area were fair to poor in pinyon-juniper and fair in sagebrush and mixed brush. However, browse conditions within these habitats were generally considered good (RBOSP Final Environmental Baseline Report, 1977). Assuming that Tract C-a (5,100 acres) supports approximately 600 AUM's (animal unit months) (8.5 acre/AUM) (personal communication, K. Russel, BLM, Meeker, CO, November, 1976), approximately 30 AUM's will be removed by mine facility and corridor construction on Tract C-a. This loss in livestock carrying capacity will be mitigated by the modification of adjacent habitat as described in this Chapter (11.2). The 261 acres of habitat to be lost also provides forage and browse for mule deer. Aerial counts indicated that more mule deer occurred on Airplane Ridge than on any other portion of Tract C-a (RBOSP Progress Report 10, 1977). This loss of habitat may force deer to modify their daily movements and migration patterns in the

vicinity of the mining facilities. However, since Tract C-a is transitional range for mule deer, the loss of 261 acres should not significantly affect deer populations in the region Small mammals and songbirds also use the area which will be lost. Rodents (e.g., least chipmunk and deer mouse) and Nuttall's cottontail will probably be destroyed or forced into surrounding areas where they may not survive. However, habitat modification and restoration programs to be implemented by RBOSP should mitigate adverse effects to small mammals to the extent that no significant decreases in any populations occur (increases in certain populations might in fact result from revegetation efforts).

An additional 1,027 acres of terrestrial habitat will be disturbed (but not destroyed) in the Commercial Phase. The processed shale disposal pile and corridor areas constitute this acreage; upland sagebrush, pinyon-juniper associations, and mixed brush are the major vegetation types involved (Table 6-11-2). Since these areas will be revegetated as soon after disturbance as practicable, the disturbance will be spread over the life of the project, and revegetated areas will provide habitat at least equal in quality to that disturbed. No long-term adverse impacts to terrestrial biota are anticipated.

The RBOSP Fish and Wildlife Management Plan is designed to mitigate unavoidable adverse impacts to fish and wildlife habitat. Means for mitigating these impacts include habitat conversion, habitat modification, construction of structural habitat, habitat restoration, and human disturbance control. Habitat conversion and modification techniques should provide additional forage and browse for domestic livestock and wildlife. Structural habitat and water availability improvements should increase the quality of existing faunal habitat. Revegetation should insure the successful and timely reestablishment of wildlife habitat in disturbed areas on Tract C-a.

RBOSP will address multiple interests (e.g., range management, wildlife resources, and protection of feral horses) and provide a balanced habitat modification program. RBOSP will coordinate all phases of the wildlife

management plan to insure that development impacts which damage or destroy habitat are mitigated.

RBOSP will coordinate all habitat alteration programs through the AOSO and will oversee the implementation of wildlife habitat alteration programs within the tract boundaries. Any activities on off-tract lands will be conducted in cooperation with the BLM and the Colorado Division of Wildlife (CDOW). Before these programs begin, RBOSP will meet with BLM and CDOW personnel to insure that the programs are compatible with future agency plans that they may have for fish and wildlife management in the Piceance Creek basin.

11.2 WILDLIFE HABITAT MODIFICATION AND RESTORATION

Literature concerning habitat enhancement techniques that might be applicable to the Piceance Creek basin has been reviewed (Table 6-11-3). General techniques that might be applicable to the Tract C-a area include:

- Modification and/or conversion of existing habitat.
- Construction and/or retention of structural habitat.
- Increasing water availability.
- Restoration of habitat lost or creation of new habitat.

A. Modification and/or Conversion of Existing Habitat - Several rangeland modification and conversion techniques are available. Most of these techniques were originally designed to improve herbage production for cattle or sheep. Research and management concerning range improvements for livestock have been underway for more than 70 years (Paulsen, 1975). More recently, concern about the value of rangeland for wildlife has become important. The effects of traditional range management practices on native wildlife are not fully understood. In many cases, however, the implementation of existing techniques can provide far more herbage and browse for livestock and wildlife than does existing rangeland (Paulsen, 1975).

Table 6-11-3

LITERATURE CONCERNING HABITAT ENHANCEMENT TECHNIQUES THAT MIGHT BE APPLICABLE TO THE PICEANCE BASIN*

Barney, M. A. and N. C. Frischknecht. 1974. Vegetation changes following fire in the pinyon-juniper type of west-central Utah. Journal of Range Management 27(2):91-96.

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Evans, R. A. and J. A. Young. 1975. Aerial application of 2,4-D plus picloram for green rabbitbrush control. Journal of Range Management 28(4):315-318.

Frischknecht, N. C. 1975. Native faunal relationship within the pinyon-juniper ecosystem. p. 55-65. In: Proceeding of pinyon-juniper symposium. Utah State University, Logan, Utah.

Gifford, G. F. 1975. Approximate annual water budgets of two chained pinyon-juniper sites. Journal of Range Management 28(1):73-74.

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Lavin, F., F. B. Gomm, and T. N. Johnson, Jr. 1973. Cultural, seasonal, and site effects on pinyon-juniper rangeland plantings. Journal of Range Management 26(4):279-285.

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Plummer, P. A. 1968. Restoring big game range in Utah. Utah Division of Fish and Game. Publication No. 68-3. 183 p.

Thatcher, A. P. and U. L. Hart. 1974. Spy Mesa yields better understanding of pinyon-juniper in range ecosystem. Journal of Range Management 27(5):354-357.

Williams, G., G. F. Gifford and G. B. Coltharp. 1972. Factors influencing infiltration and erosion on chained pinyon-juniper sites in Utah. Journal of Range Mangement 25(3):201-205.

* See Literature Cited for pertinent references.

1. Habitat Conversion - Habitat conversion is usually designed to replace dense stands of woody vegetation (e.g., pinyon-juniper or sagebrush) with more productive and palatable grasses, forbs, and woody plants. Conversion typically removes all or part of the existing woody vegetation by mechanical or chemical methods or through burning.

Mechanical methods include crushing, chopping, rotocutting, chaining, railing, cabling, bulldozing, harrowing, disking, and undercutting. The physical removal of undesirable woody plants may be accomplished by any of these methods. Many of these methods are either quite expensive; applicable only on small, level, or rock-free areas; or are not suitable in very dense, uneven-aged stands or stands containing larger trees.

Chaining is probably the most commonly used method for clearing unproductive western rangeland (Aro, 1971). A heavy chain (each link weighing 25 to 90 pounds) is pulled by two large crawler tractors. The chain, 200 to 600 feet long, assumes a U-shaped configuration between the tractors and effectively removes woody vegetation. Chaining is easier in rough terrain than are most other mechanical methods. Different size chains work better in different situations. Chains with links that weigh 70 pounds or more eliminate young, supple trees better than lighter chains; a section of railroad rail welded across each chain link enhances the killing ability of the chain. If it is desirable to retain smaller understory plants, a lighter chain is used. Single chaining (chaining in one direction) is often not as effective as double chaining (chaining in opposite directions), especially in uneven-aged stands or stands less than 10 feet tall (Aro, 1971). Double chaining is usually better than single chaining because more trees are killed and the rate of reinvasion by trees is slowed.

Chaining has successfully increased the productivity of rangeland formerly dominated by pinyon-juniper and sagebrush. Chaining helps to increase forage production by reducing competition for water, releasing the understory from shade, and creating bare soil that is conducive to the germination and establishment of desirable forage species.

Chemical methods applicable to rangeland conversion include foliage spraying (blanket or selective), stem spraying (with or without girdling and/or injection), and application of soil sterilants (or herbicides that selectively kill broad-leaved plants only). Blanket spraying of foliage is probably the only economically feasible chemical technique that might be used for habitat enhancement on and near Tract C-a because of the relatively large size of the areas that might be involved. Blanket spraying has been used successfully for sagebrush control. Chemical control of pinyon-juniper is relatively new and has not been fully studied (Aro, 1971).

Chemical spraying usually results in an increase in the production of herbage, but the duration of woody plant control is of concern. Herbage production began to decrease 5 years after spraying sagebrush in Wyoming (Johnson, 1969). Thilenius and Brown (1974) also noted that chemical control of big sagebrush in Wyoming was short-lived. Chemical clearing methods are not recommended for use on Tract C-a because they are apparently not a proven and tested method on pinyon-juniper (Aro, 1971). They control sagebrush but their effectiveness usually lasts for less than 15 years (Thilenius and Brown, 1974). Public concern and government regulations restrict the use of chemicals on Tract C-a.

Burning is an effective means of habitat conversion under the proper conditions. Burning may consist of the killing of individual plants with torches or the controlled use of fire over larger areas to kill woody plants (wildfire, although not planned, may produce the same results). Fire can be effective for converting pinyon-juniper to grassland. Where vegetation is dense enough to support an effective fire, controlled burning should be the primary technique for pinyon-juniper conversion (Aro, 1971). In hilly areas, burning often leaves pockets of vegetation that resprout and result in improved forage for both livestock and wildlife (Arnold et al., 1964). Burning is possibly the best method to remove large areas of undesirable species quickly and cheaply; good kills are common and seedbed preparation is excellent (Aro, 1971). Unfortunately, controlled burning has several serious drawbacks: it is

potentially hazardous; it creates air pollution; it is not accepted by the public in many areas; and, its most desirable attribute (elimination of woody vegetation over large areas) may be very beneficial for herbage production for livestock, but may be detrimental to certain species of wildlife. Because of the amount of pinyon-juniper on the tract, controlled burning should be used in the habitat enhancement program. However, its use should be restricted to local application in specific areas.

2. Habitat Modification - Habitat modification techniques that might be used in the RBOSP habitat enhancement program include aerial seeding, fertilizing, interseeding, and small-scale mechanical preparation of seedbeds for planting. All of these methods could be used in conjunction with the habitat conversion techniques discussed previously and, possibly, in the restoration of habitat (discussed later in this chapter). Habitat modification techniques might also be used to enhance areas that do not require conversion or restoration (e.g., areas without dense woody cover or those where undesirable non-woody species are dominant).

3. Recommendations - Pinyon-juniper, and possibly sagebrush scrub, on and near Tract C-a are probably most amenable to habitat conversion. Any modification of habitat conducted will be implemented in a way that will benefit native wildlife as well as livestock. Mechanical conversion techniques and limited controlled burning are recommended for removing woody vegetation. For pinyon-juniper conversion, the following sequence is possible:

- Double chain (in opposite directions) where appropriate.
- Windrow at least a portion of the woody debris.
- Burn selected areas (after chaining) if possible.
- Apply fertilizer and broadcast seed where applicable.
- Use aerial seeding for large areas if appropriate.
- Rechain (one direction) with light chain to cover seed.

All of the steps in this sequence may not be necessary. Actual practices used in the field will vary, depending on conditions present at each specific treatment area. The number and size of areas to be manipulated and the specifics of the techniques to be used will be determined through consultation between RBOSP and appropriate state and federal agencies. General guidelines for the implementation of pinyon-juniper conversion and/ or improvement follow:

- Locate treatment areas in dense, relatively pure stands where the erosion hazard is low to moderate at most.
- Locate treatments in areas with understory species that have a good potential for increasing forage and browse production.
- Select specific treatment areas that are relatively small and irregularly-shaped.
- Do not treat a substantial percentage of existing pinyon-juniper habitat at the same time.
- Leave as much slash as practicable in the treatment area to build windrows and brushpiles.
- Leave "islands" of vegetation around snags (dead standing trees) and live trees known to contain nest holes.
- Maintain buffer strips of natural pinyon-juniper (1/8 to 1/4 mile wide) between treatment areas.

The maintenance of undisturbed vegetation types adjacent to modified areas will provide a variety of wildlife habitat. The ecotone created should support more animal species and the undisturbed habitat would provide important shelter.

If sagebrush conversion or improvement is used, the same general procedures recommended for pinyon-juniper should be considered. Depending on the desired results of woody plant manipulation, railing might be used in place of chaining. Small, discrete segments of rank sagebrush stands should be selected for treatment and more emphasis should be given to possible burning and reseeding.

4. Anticipated Results - The principal effect of habitat manipulation would be an increase in available forage and browse for large domestic and feral herbivores. Dense stands of pinyon-juniper and sagebrush do not provide substantial amounts of forage for large herbivores. Chaining of closed canopy stands of pinyon-juniper or sagebrush increases forage for livestock. Mule deer are the most important game species on Tract C-a. Much of the pinyon-juniper vegetation type on Tract C-a is used as transitional range by mule deer (Section 7, Chapter 2). Chaining of portions of dense pinyon-juniper stands would increase the amount of food available to mule deer. Elk and feral horses might also benefit from the increase in available forage.

Selected modification of pinyon-juniper and possibly sagebrush on or near Tract C-a would also enhance the habitat available for other species of wildlife (Springfield, 1976). Small mammals, songbirds, game birds, and raptors would, in many cases, benefit from the diversified habitat resulting from manipulation. Wildlife species diversity and abundance are usually greater in ecotones than in pure stands of homogeneous vegetation. The retention of snags and live trees known to contain nesting cavities would benefit a variety of birds. Populations of several species of small mammals could increase substantially in the grassland/scrub habitat created by the manipulation of pinyon-juniper or sagebrush. The duration of increased small mammal populations would depend somewhat on the rate of reinvasion of woody plants into treatment areas. In the interim, however, food availability and hunting conditions for many raptors would be enhanced. Game species, other than mule deer, that could benefit from habitat manipulation include cottontails, mourning doves, and sage grouse. Cottontail production may increase due to increased forage production and protective cover, (e.g., brushpiles and windrows). Forage production, especially of small shrubs and grasses, will be greatly increased through habitat manipulation. The openings created by sagebrush and pinyon-juniper conversion should provide additional sage grouse nesting, booming, and feeding grounds. The mourning dove, the most widely distributed game bird on the site, may be adversely affected by removal of pinyon-juniper stands. Mourning doves

nest in pinyon-juniper and upland sagebrush habitats. However, populations of mourning doves should not be seriously affected if bands of pinyon-juniper are left undisturbed. Also, increased food supplies should be available in the modified areas.

B. Construction and/or Retention of Structural Habitat - Improvement by construction of structural habitat (e.g., brushpiles, windrows) may benefit many species of wildlife. The proper placement of brushpiles or windrows during habitat modification and construction activities could provide protective cover for small mammals, birds, and lizards. Sagebrush lizards, the most abundant reptile on the study area, might use brush piles as protective cover. Brush piles would also provide perches for songbirds. Vantage points are critical to successful territory establishment by many breeding songbirds (Verner, 1975). Cottontails and jackrabbits use brush piles, felled trees, or windrows as protective habitat. Structural improvements and increased forage production may result in increased cottontail production, which in turn could result in greater availability of cottontails to hunters and predators. The retention of snags or selected living trees will provide perches, and possible nest sites, for raptors.

To the extent practicable, suitable materials removed in site preparation will be used to improve protective cover for wildlife. Care will be taken to assure that the placement of such materials will not be counterproductive to revegetation efforts, (e.g., that barriers are not created for wildlife and that wildlife is not concentrated in hazardous areas). However, the greatest structural habitat improvement will result from habitat modification, (e.g., chaining of the large stands of pinyon-juniper and sagebrush).

C. Modifying and/or Increasing Water Availability - RBOSP will mitigate effects resulting from mine dewatering. Adverse effects of water loss, (e.g., dry springs, loss of riparian habitat) could be mitigated by building permanent runoff collectors (guzzlers). These runoff collectors could enhance wildlife use of areas that are presently "dry" but otherwise

contain suitable wildlife habitat. The number and location of runoff collectors to be built would be determined by RBOSP in consultation with the AOSO. Sites should be on gentle north-facing slopes to minimize evaporation and elevated water temperatures due to solar radiation. The runoff collectors should not be placed where they might cause significant increases in predation. For example, suitable escape cover should be accessible, but dense vegetation that might prevent the detection of predators by wildlife using the guzzlers, should be avoided. Typical guzzlers consist of three basic components: the apron, the cistern or tank, and an enclosed ramp. Details of guzzler construction and placement will be determined by RBOSP if and when their use is deemed appropriate.

D. Restoration of Habitat - Disturbed land that will require restoration after construction and disposal includes:

- Areas disturbed by construction, (e.g., access roads, support facilities, water-control structures, and pipelines).
- Raw and processed shale disposal areas.
- Surface soil storage areas.

RBOSP has developed a revegetation plan for disturbed areas that is in accordance with the lease and state requirements. This plan is presented in detail in Section 6, Chapter 8.4. The revegetation plan is designed to create habitat that is at least as valuable for wildlife as habitat presently existing on and in the vicinity of Tract C-a.

Disturbed land will be reclaimed to support similar animals that presently exist in the area by restoring vegetation that is similar in species composition to that previously existing in the area. Therefore, if a shrub community is disturbed, the emphasis of the revegetation will be to reestablish the important shrubs of the disturbed habitat by the techniques described in Section 6, Chapter 8.4. Important shrubs include those species which are used by animals for food and cover or that are abundant in that habitat type.

During the 30-year period of the project, 1,475 acres of disturbed land will require revegetation. The raw shale ore and processed shale disposal piles will constitute approximately 85% of the area disturbed. Reclamation of the disposal piles will involve a long-term effort over the 30-year period. The proposed schedule for revegetation is presented in Table 6-11-1.

Plant species to be seeded will be selected from a list of species which are broadly adaptable to the environmental conditions on Tract C-a. Species selected will provide a diversity of forage and browse species for livestock and wildlife and will be seeded in a composite mixture of grasses, forbs, and shrubs. The early introduction of shrubs is expected to rapidly reestablish suitable wildlife habitat. The final species composition of the revegetated areas is impossible to predict and will depend on the available natural seed source in the area, climatic conditions during succession, and grazing effects by domestic animals and wildlife. Fertilizer or mulch will be applied as required by site conditions.

To ensure restoration of lands affected by processed shale disposal, RBOSP has designed an "artificial soil profile". This profile is expected to reduce the adverse chemical and physical effects of the processed shale by preventing upward movement of toxic elements by capillary action and thereby provide a suitable medium for germination and establishment of preferred plant species. The raw shale ore disposal pile will be covered with surface soil to enhance plant establishment (see Section 6, Chapter 8.4).

RBOSP is currently investigating available technology to obtain additional information specific to Tract C-a which will further insure successful habitat restoration. Success of the RBOSP revegetation efforts will be monitored throughout the project (See Section 8, Chapter 7) and any areas not adequately revegetated as determined by the AOSO and RBOSP will be reseeded. Successful revegetation of disturbed areas will restore faunal habitat in accordance with the lease agreement.

11.3 HUMAN DISTURBANCE CONTROL

Oil shale development on Tract Ca will result in increased human activity on and near the tract. Increased human activity could cause substantial adverse impacts to some biota. The potential for adverse impacts would be greatest during the construction phase because of the large number of construction personnel required.

RBOSP will provide educational, restrictive and/or structural means to help reduce adverse impacts from increased human disturbance on and near Tract C-a. Major potential impacts include an increase in:

- Vehicle-animal collisions.
- Hunting (legal and illegal).
- Off-road use of vehicles.
- General harassment of wildlife by humans or their pets.

Brief discussions of each major impact and methods proposed for controlling the magnitude of these impacts follow.

Increased traffic along existing and planned roads in the vicinity of Tract C-a will probably result in increased wildlife mortality from vehicle-animal collisions. Mule deer are of special concern because they can cause extensive vehicle damage and human injury and because mule deer are valuable big game animals. Means to help reduce roadkills of wildlife in the Tract C-a area will include:

- Public information - RBOSP will develop a brochure for employees and visitors which discusses the important game and wildlife species, and their associated habitats, which occur on and in the vicinity of Tract C-a. This brochure will include a description of animal behavior patterns and suggest driving habits that might reduce the likelihood of collisions.
- Restrictions - Speed limits will be posted on tract.

- Structural methods - Deer crossing signs will be installed at appropriate intervals along major roads in the vicinity of the tract.

The influx of people into the Tract C-a area will probably increase hunting and trapping pressure on wildlife in the area. The current utilization of wildlife resources in the area is discussed in Section 7, Chapter 2. Legal hunting pressure on mule deer in the Piceance Creek basin is high, but hunting pressure on small game species is relatively low. Poaching, though difficult to quantify, is a problem in the basin. RBOSP has no jurisdiction over legal hunting in areas of Tract C-a that are open to the public. However, the following steps will be taken to attempt to reduce any adverse impacts of legal or illegal hunting associated with Tract C-a development:

- Public information - A brochure will be developed to inform employees and visitors of regulations governing hunting, fishing, and trapping. This information will also be posted in conspicuous places as per lease stipulations. The brochure will present general information on important game and wildlife species and their associated habitat.
- Restrictions - Hunting and trapping on restricted portions of Tract C-a will be prohibited. RBOSP will consider the conviction of any employee for job-related game violations as grounds for disciplinary action.

The off-road use of vehicles can have adverse effects on vegetation and wildlife. Indiscriminate use of vehicles often results in habitat destruction by destroying vegetation, compacting soil or snow, and inducing erosion. Direct disturbance to individual animals during critical times, such as winter and breeding seasons, is also a potential problem. Recreational vehicles (e.g., motorcycles, snowmobiles, dune buggies) can be a special problem. Appropriate control measures will be initiated through cooperation among RBOSP, AOSO, and other government agencies. RBOSP will regulate off-road vehicle use, to the extent

possible, for both safety and wildlife protection, by the following means:

- Public information - A brochure will inform employees and visitors that off-road use is limited as a safety precaution and because of potential ecological damage.
- Restrictions - All vehicles traveling on Tract C-a will be restricted to designated roads. Construction equipment will be limited to designated roads, construction areas, or disposal areas.
- Structural methods - Access to newly reseeded, enhanced, or other sensitive areas being restored will be blocked by fences or other barriers.

In addition to potential impacts from vehicular and hunting pressure, the physical presence of more people and their pets will probably affect the distribution and behavior of wildlife in the vicinity of Tract C-a. Lease stipulations allow public access for legal consumptive and non-consumptive uses of wildlife in unrestricted portions of the tract. Procedures to be used by RBOSP to minimize unnecessary disturbance to wildlife by humans and their pets include:

- Public information - A brochure will inform employees and visitors of the potential adverse effects of wildlife harassment by humans or their pets.
- Restrictions - Unnecessary disturbance of wildlife by RBOSP employees or their pets will be prohibited.

11.4 MONITORING PROGRAM

A comprehensive monitoring program has been developed to assess the effectiveness of the Wildlife Management Plan. The effectiveness of the plan will be evaluated by comparing various terrestrial parameters at control and experimental (treatment) sites before modification and

at specified intervals after the habitat modification procedures are completed. RBOSP will cooperate with AOSO and appropriate government agencies in evaluating the success of the program and, if necessary, in modifying future aspects of the program.

A. Terrestrial - The terrestrial habitat modification monitoring program is summarized in Table 6-11-4. Additional details regarding methodology are presented in the terrestrial monitoring program in Section 8, Chapter 4.

1. Parameter 1 - Range Productivity and Utilization

a. Objectives and Rationale - The quantity of available forage will be reduced as a result of Tract C-a development. Habitat modifications (treatments) will be applied in areas adjacent to disturbance to enhance the quality of forage for certain animals. The range productivity and utilization studies were designed to detect changes in forage productivity and wildlife use which result from implementation of the proposed wildlife management plans.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in the range productivity or range use between the experimental and control sites before treatment; after treatment.

H_o: There is no significant difference in range productivity or range use in the experimental site before and after treatment; in the control site before and after treatment.

c. Methods - Sampling will be conducted on experimental (treatment) and control areas. The location of the sites will be selected prior to initiating the habitat modification. Forage will be measured at the end of the growing season (September) in the year preceding treatment and annually in years 1, 3, and 5 after treatment. Forage productivity will be measured by the double sampling method

Table 6-11-4

SUMMARY OF THE PROGRAM TO EVALUATE THE RBOSP FISH AND WILDLIFE MANAGEMENT PLAN FOR OIL SHALE TRACT C-a

Samplings Program	Parameter	Sampling Frequency	Sampling Technique	Sampling Intensity	Data Analyses
VEGETATION	Species Composition	Before modification, Year 1,3,5...	Quadrat (9.6 sq ft)	1 Transect/2 ha (5 acres) (10 plots each - 10m intervals)	Coefficient of Community (CC) Percent Similarity (PS) (Pielou 1974)
	Percent Cover	Before modification, Year 1,3,5...	Quadrat (9.6 sq ft)	1 Transect/2 ha (5 acres) (10 plots each - 10m) intervals)	Coefficient of Community (CC) Percent Similarity (PS) (Pielou 1974)
	Productivity & Utilization	Before modification, Year 1,3,5...	Quadrat (9.6 sq ft) Double Sampling Method (USDA, 1970)	1 Transect/2 ha (5 acres) (10 plots each)	Analysis of Variance (AOV); Multiple Range Test
	Browse Condition & Utilization	Before modification, Year 5	Cole (1963).	1 Transect/2 ha (5 acres) (25 individual)	Analysis of Variance (AOV); Multiple range test
FAUNA	Small Mammals Species Composition Index of Abundance	Before modification, Year 1,3,5...	Pit trapping Live trapping	5 Groups (2 transects of 10 traps/group) *	Regression Analysis; F-test; Analysis of Variance (AOV) Index of Abundance
	Avifauna Species composition Map of Territories Density of Breeding Birds	Before modification, Year 1,3,5...	Breeding bird mapping technique (Graul 1976; Hall 1964; Robbins 1970)	12-45 ha(30-105 acres) (depending on habitat) divided into 1 ha subunits; 8 replicates of subunits *	Regression Analysis; Analysis of Variance (AOV) (for density only)

* Sampling will be examined during first year study to determine adequate sampling intensity.

(USDA (Region 2), 1970) (1 transect/5 acres of habitat). Transects will be selected randomly within the treatment and control areas. Determination of adequate sample size, based on percent cover indicates that 100 plots will achieve an accuracy of ±25% of the mean 90% of the time.

Two caged plots (9.6 sq. feet in size), and eight unprotected plots (permanently marked) will be located along each sample transect. Sampling will be done using a 9.6 sq. foot sampling loop on each of eight unprotected plots. Production of the dominant grass and forb species (species making up 90% of the individuals) within the loop will be estimated by ocular weight to the nearest gram. Species providing less than one percent biomass will be recorded as present, but will not be weighted. The two protected plots will be clipped, bagged separately, weighed green and recorded. Correction factors will be calculated from the estimated green weights and actual green weights of the clipped plots. Samples will then be air dried and weighed to obtain dry weights.

Potential vegetation damage from insect, frost, or gaseous emissions (SO_2 or NO_x) will be qualitatively assessed. Any damage will be recorded and an estimate of damaged vegetation will be calculated to determine the precent of the sampled vegetation which was affected.

d. Experimental Design and Data Analyses - Data collected on the control and experimental sites will be analyzed by means of an analysis of variance (AOV). Data collected before treatment will be used to test between site differences. After treatment, a two-way AOV will compare treatment effects, time effects, and a treatment x time interaction. If the interaction effect is significant, a multiple range test will be performed to determine the source of the interaction.

2. Parameter 2 - Browse Utilization

a. Objectives and Rationale - The quantity of available browse will be reduced as a result of Tract C-a development. Habitat modifications (treatments) will be applied in areas adjacent to disturbance

to provide additional browse for animals. The browse utilization studies were designed to detect changes in wildlife use of browse which result from the proposed wildlife management plans.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in browse utilization between the experimental and control sites before treatments; after treatments.

H_o: There is no significant difference in browse utilization in the experimental site before and after treatment; in the control site before and after treqtment.

c. Methods - Sampling will be conducted on the experimental and control sites which will be selected prior to habitat modification. Browse will be measured in early May (after deer have migrated through the Tract C-a area) in the year preceding treatment and in year 5 after treatment.

Browse utilization will be estimated along transects (1 transect/5 acres) consisting of 25 individual shrubs (Cole, 1963). Transects will be selected randomly within the experimental and control sites. Data collected during the first year will be used to determine the number of transects necessary to achieve an accuracy of ±25% of the mean 90% of the time.

Browse species to be sampled include: juniper (Juniperus osteosperma), pinyon (Pinus edulis), antelope bitterbrush (Purshia tridentata), snowberry (Symphoricarpos oreophilus), big sagebrush (Artemisia tridentata), and true mountain mahogany (Cercocarpus montanus).

Form class, age, leader use, hedging and availability will be measured.

Potential vegetation damage from insect, frost, or gaseous emissions (SO_2 or NO_x) will be qualitatively assessed. Any damage will be recorded

and an estimate of damaged vegetation will be calculated to determine the percent of the sampled vegetation which was affected.

d. Experimental Design and Data Analyses - Data collected on the control and experimental sites will be analyzed by an AOV. Data collected before treatment will be tested to determine between site differences. After treatment, a two-way AOV will be used to compare treatment effects, time effects, and a treatment x time interaction. If the interaction effect is significant, a multiple range test will be performed to determine the source of the interaction.

3. Parameter 3 - Species Composition and Percent Cover

a. Objectives and Rationale - Habitat modification is designed to improve the quality of existing habitat and will affect the species composition and the percent vegetative cover in the treated areas. Species composition and percent cover will be sampled to determine the changes resulting from treatment.

b. Hypothesis - No statistical hypothesis will be tested.

c. Methods - Species composition and percent cover will be determined concurrently (before treatment and annually during years 1, 3, and 5) with the range productivity and utilization studies. The percent cover of each species in the 9.6 sq. foot plots (10 plots/transect and 10 transects/site) will be estimated and recorded. Sampling will achieve an accuracy of $\pm$25% of the mean 90% of the time.

d. Experimental Design and Data Analysis - Data collected on the control and experimental sites will be compared before and after treatment by calculating a coefficient of community (CC) and a percentage similarity (PS) (Pielou, 1974). Comparisons before treatment will determine the degree of similarity between the control and experimental sites. Comparisons after treatment should indicate a reduced similarity

since a successful habitat modification program should benefit plant species different than those occurring prior to modification.

4. Parameter 4 - Small Mammal Abundance

a. Objectives and Rationale - A variety of small mammal species have been found on Tract C-a. Small mammals are important components of the diets of many predators. Small mammals also act as seed dispersal agents and compete with other animals for certain food items. Oil shale development on Tract C-a should have no adverse impacts on regional small mammal populations. Habitat enhancement and revegetation programs proposed by RBOSP will increase the amount of food and cover available for certain species of small mammals.

The objective of small mammal monitoring studies is to evaluate the response of these species to the habitat modification programs proposed by RBOSP.

b. Hypothesis

H_o: Small mammal population levels are not significantly changed by habitat modification.

c. Methods - Sherman live traps, baited with peanut butter and bird seed, will be used. Five trap groups (2 lines of 10 traps each) per sampling area will be used during the first year (see Subsection d). The total number of trap groups and the number of sampling days required will also be determined during the first year. Traps will be checked twice a day (morning and evening) so that data for nocturnally and diurnally active species are obtained. Animals captured will be identified, sexed, aged (adult or immature) and released at the point of capture.

Pit-traps will also be used. Approximately 10 pit-traps will be established in each small mammal sampling area. These traps will be placed in locations where shrews or other small mammals might be captured.

d. Experimental Design and Data Analyses - Small mammal trapping will be conducted on modified and control areas before and after modification. Control areas will be established in habitat similar to that in areas to be modified. Sampling intensity (numbers of sampling areas and trap groups) sufficient to provide indices of small mammal abundance that are within 20 percent of the mean, 80 percent of the time will be determined during the first year. Sampling will be conducted during the spring and fall (small mammal populations are typically lowest in spring and highest in fall).

An index of abundance (number captured per 100 trap days) will be calculated from live-trapping data (for each sampling area). Data collected before the Modular Development Phase begins will be compared with that collected in subsequent years. Statistical tests will include F-tests, and analysis of variance and regression analysis where appropriate (Seber, 1973).

Both live-trapping and pit-trapping data will be used to describe the species composition of small mammals in the areas sampled. These data will not be treated statistically.

5. Parameter 5 - Avifauna

a. Objectives and Rationale - Many species of birds were observed on Tract C-a during baseline studies. Bird groups present in the RBOSP study area include waterfowl, shorebirds, raptors, upland gamebirds and songbirds. Tract C-a development is not likely to have significant adverse effects on any regional avifauna populations. Habitat enhancement and revegetation programs proposed by RBOSP will increase the amount of food and cover available for certain species of birds. Songbirds, especially those that breed on Tract C-a, are most likely to be affected by habitat modification programs.

The objective of avifauna studies during the monitoring program is to evaluate the response of breeding songbirds to habitat modification programs proposed by RBOSP.

b. Hypothesis

H_0: Breeding songbird densities are not significantly changed by habitat modification.

c. Methods - The breeding bird mapping technique will be used. Each study unit will be divided into one ha subunits (2.47 acres). An observer will search each subunit and record species, location and breeding activity (e.g., territorial defense, singing) of avifauna observed. The location and contents of nests observed will also be noted. Replicate samples of each subunit will be obtained. Sampling intensity (number of subunits and replicates) will be determined during the first year of the study (see Subsection d).

Breeding bird mapping studies will be conducted during the peak songbird breeding period (late May-early June). A map showing territories and nest locations will be prepared for each subunit. Additional information concerning avifauna in the RBOSP study area will be collected, by general observation, during the spring, summer, and winter (gamebirds and raptors will receive special emphasis).

Avifauna study units will be established in areas to be modified and in control areas (control areas will contain habitat similar to that to be modified). Breeding bird mapping (Graul, 1976; Hall, 1964; Robbins, 1970) will be conducted in control and modified areas, before and during development activities. Study units will be 12 or 42 ha (30 or 105 acres) depending on the openness of the habitat type being sampled. Date collected during the first year will be used to determine the number of subunits and replication of counts on subunits required to estimate population densities of breeding birds on the study unit within 20 percent of the mean, 80 percent of the time.

d. Experimental Design and Data Analysis - The numbers of breeding birds found in each subunit will be used to calculate the density of breeding songbirds in each study unit. Statistical comparisons

of density estimates for control and modified areas will be performed (regression analysis and an F-test in conjunction with analysis of variance (Seber, 1973; Overton, 1971). Territory size and reproductive effort for each species in each study unit will be assessed qualitatively (from maps and field data). Lists of birds observed during qualitative habitat searches will be prepared.

B. Aquatic - The intent of the RBOSP water quality control plan is to avoid disturbance of the existing water quality and the flora and fauna of aquatic habitat. Since no fish exist on tract, the aquatic monitoring program discussed in Section 8, Chapter 5 will be adequate to assess effectiveness of water control plans.

11.5 IMPLEMENTATION

The objective of the Fish and Wildlife Management Plan is to minimize impacts to fish and wildlife. The proposed plans were designed to minimize unavoidable impacts and to mitigate damage or destruction of wildlife habitat by improving the quality of remaining habitat for wildlife.

Various means for accomplishing this have been described, including restoration of disturbed habitat by revegetation, modification of existing undisturbed habitat to increase productivity and diversity, construction of structural habitat to increase habitat availability, and construction of water sources to increase use of adjacent habitat. Stress to wildlife caused by increased use of wildlife habitat by humans may be mitigated by providing the public with information regarding wildlife in the area and explaining the impact of human presence on wildlife. This approach has the advantage of increasing the public's concern about wildlife and enhancing their enjoyment of natural resources.

The methods and recommendations described in previous sections of this chapter provide the framework for the management plan as described in Section 4 (A) of the Oil Shale Lease Environmental Stipulations. RBOSP

will encourage input from involved agencies and will cooperate closely with these agencies to achieve maximum effectiveness of the mitigation procedures.

AOSS will be periodically informed of the success of the mitigation procedures as determined during monitoring studies. If mitigation measures fail to meet the objectives established in the Fish and Wildlife Management Plan, the methods will be reevaluated and modified as necessary to achieve desired goals.

CHAPTER 12

PROTECTION OF OBJECTS OF SCIENTIFIC & HISTORIC INTEREST

SECTION 6

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER 12
PROTECTION OF OBJECTS OF HISTORIC AND SCIENTIFIC INTEREST

During the two-year baseline period, intensive cultural resource surveys were conducted on and in the vicinity of Tract C-a to determine the presence or absence of significant cultural resources, and impending impacts of proposed development on such cultural resources. Recommendations for salvaging or avoiding any adverse impacts to these resources. were made on the basis of these surveys. Towards this end, archaeologic, historic and paleontologic studies were conducted. Following completion of field surveys and laboratory analysis, a Cultural Resources Survey Report was published (RBOSP, October 1976). Within the next few months this report and recommendations contained therein were carefully reviewed by the Area Oil Shale Supervisor, the Bureau of Land Management, the State Historic Preservation Officer and the Advisory Council on Historic Preservation. The recommendations presented herein are in compliance with the determinations established by the Bureau of Land Management in consultation with other responsible agencies.

12.1 CULTURAL RESOURCES REGULATIONS

The cultural resources inventory described in the Cultural Resources Survey (RBOSP, 1976) was performed in compliance with stipulations set forth in Tract C-a Oil Shale Lease Environmental Stipulations and References (U.S. Dept. Interior, Bureau of Land Management), the Antiquities Act of 1906, the National Historic Preservation Act of 1966 (as defined in 36 CFR 800), the National Environmental Policy Act of 1969, the Archaeological and Historic Preservation Act of 1974, Executive Order 11593 of 1971, 40 CFR Part 1500 - Guidelines for the Preparation of Environmental Impact Statements, the Colorado State Antiquities Act of 1973, and the Colorado Land Use Act of 1974.

Compliance with the above Federal and State regulations pursuant to the stipulations set forth in the above mentioned lease was achieved by:

- Searching State site files for historic and archaeologic resources and contacting the State Historic Preservation Officer for additional information on these resources.
- Searching the literature for background information on the cultural resources of the area.
- Searching the National Register of Historic Places for Rio Blanco County, Colorado.
- Conducting an intensive (100%) survey of the cultural resources of the proposed development area.
- Compilation of a report on the archaeologic, paleontologic and historic sites in the area, including an inventory of cultural sites and an evaluation of the importance of cultural sites to the National Register of Historic Places based on criteria set forth in Federal Register, Vol. 41(82), 27 April 1976.
- Affording the State Historic Preservation Officer the opportunity to comment on the report and the subsequent submission of the revised report to the Advisory Council on Historic Preservation for review and comments pursuant to the Historic Preservation Act of 1966.
- Implementation of preservation measures according to procedures outlined in 36 CFR Part 800.

On January 6, 1977, the AOSS received a "Determination of Effect" from the Colorado State Office of the BLM. This Determination of Effect was prepared in compliance with Executive Order 11593, Section 106/2b procedures. On February 3, 1977, Mr. Dale Andrus, Director of the Colorado State Office of the BLM, received a letter of concurrence from Mr. Bruce E. Rippeteau, State Archaeologist, for the State Historic Preservation Officer. This letter was followed on February 15, 1977 by a second letter of concurrence from Mr. James E. Hartman, Curator, State Historic Preservation, for the State Historic Preservation Officer. The guidelines outlined in this statement were designed to provide protection for

significant cultural resources that might be impacted by open pit mining procedures as described in the RBOSP DDP of March 1976. The current revised DDP proposes to develop oil shale by MIS methods and as such will affect considerably less acreage than the originally proposed plan (see Section 6, Chapter 12). RBOSP has therefore requested that the BLM revise the January 1977 Determination of Effect to reflect MIS mining methods. RBOSP proposes to adhere to the guidelines provided in the January 6, 1977 Determination of Effect and any subsequent revision for protection of cultural resources during development of Tract C-a by the MIS process. Should it become necessary to disturb any additional areas not previously investigated by a qualified archaeologist and/or historian, RBOSP will engage such an individual to survey the area and evaluate its potential prior to the disturbance.

12.2 DETERMINATION OF SIGNIFICANCE

After review of the Cultural Resources Survey (RBOSP, 1976), the BLM determined that two sites in the survey area (Figure 6-12-1) may be eligible for the National Register of Historic Places. One area identified in the report as Site Cluster II, is located to the east and north of Tract C-a and encompasses portions of 84 Mesa, Corral Gulch, Yellow Creek and Stakes Springs Draw drainages. The second site, 5RB13 (which lies in the vicinity of Cluster I), is located in the southeast corner of the tract. Both of these are archaeologic sites. No historic sites in the area were deemed significant.

12.3 MEASURES TO AVOID ADVERSE EFFECTS

Measures employed by RBOSP to avoid adverse effects to the above mentioned cultural resources will comply with recommendations stated in the Determination of Effect. They are as follows:

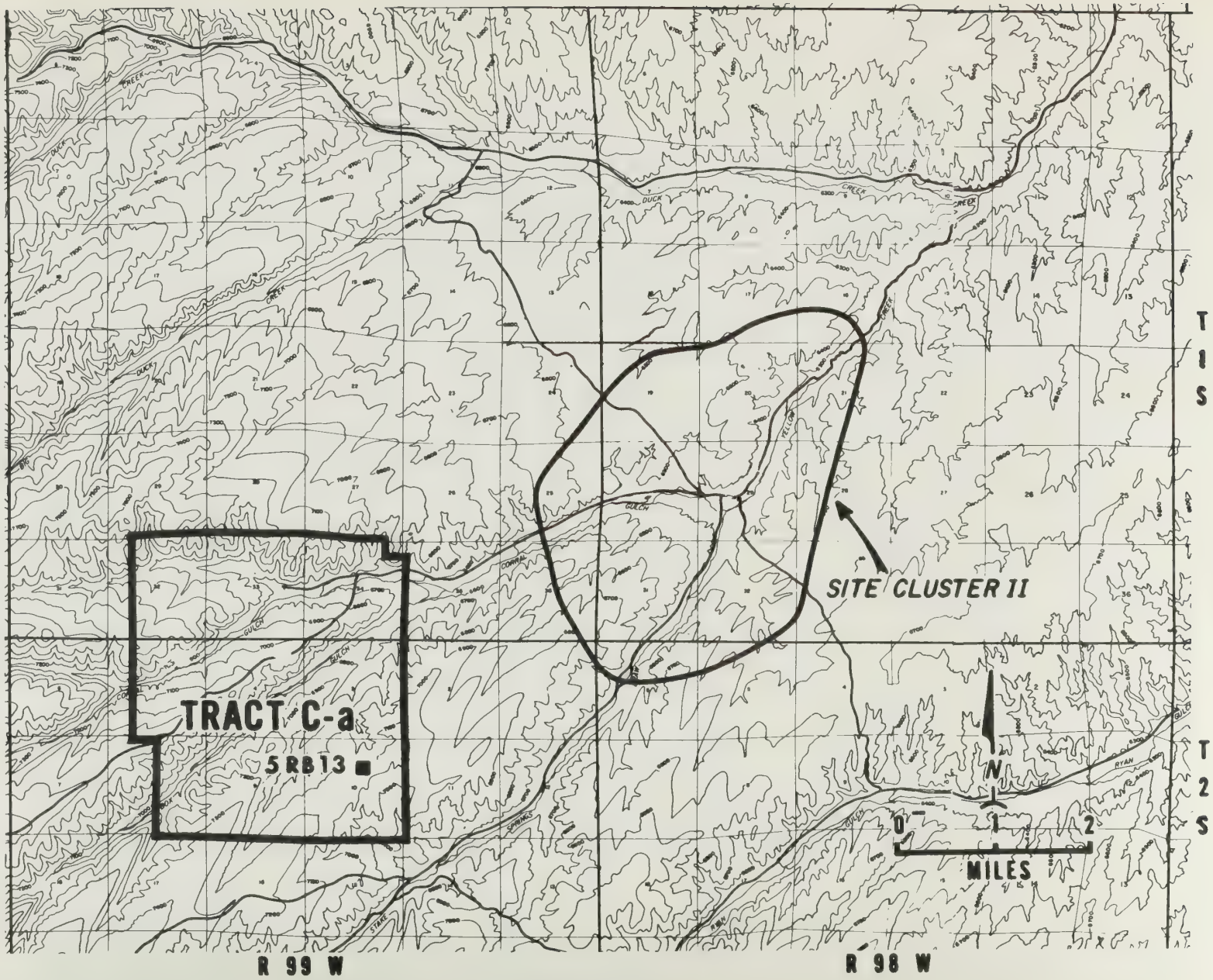

Figure 6-12-1

LOCATION OF ARCHAEOLOGIC SITES NOMINATED TO NATIONAL REGISTER OF HISTORIC PLACES

- "Site Cluster II shall be avoided wherever possible during the construction and operation phases of the proposed plan. Site Cluster II, located near 84 Mesa, will not be affected by most construction. The sites that MAY be affected shall be flagged and primary sites will be tested and salvaged by a qualified archaeologist upon disturbance or threat of disturbance. All artifacts removed shall be mapped, recorded and then curated by an approved institution and/or laboratory."
- "Site Number 5RB13, which is located on Tract C-a shall be tested and if necessary excavated by a qualified archaeologist (prior to disturbances). All materials shall be mapped, recorded, photographed and curated by an approved institution or laboratory."
- "The lessee shall immediately bring to the attention of the lessor, through the Mining Supervisor, any and all antiquities or other objects of historic or scientific interest including but not limited to historic or prehistoric ruins, fossils, or artifacts discovered as a result of operations under this lease and shall leave such discoveries intact until told to proceed by the Mining Supervisor. In cases where salvage excavation is necessary, the cost of such excavations shall be borne by the lessee."

12.4 IMPLEMENTATION OF MITIGATION MEASURES

A. Development, Planning and Scheduling - Inadvertent damage to cultural resource sites will be prevented by pre-planning of activities to avoid sites recommended for protection. RBOSP coordinators will be supplied with maps and legal descriptions of significant cultural resource sites and will be required to continuously scrutinize development activities in the aforementioned areas. Once disturbance is at hand, threatened sites will be flagged and a qualified archaeologist will be engaged to test primary sites within Site Cluster II and/or Site 5RB13. The archaeologist will be engaged in ample time to complete testing and salvage of the site before disturbance occurs.

B. Equipment Operator Training - Equipment operators will be provided with enough information to recognize the presence of historic and scientific resource material, particularly that which is in the sub-surface. In the event potentially significant historic or scientific resource material is unearthed, work will stop in the immediate area until the find is cleared and permission to resume operations has been granted by the AOSS. All finds will be reported to the BLM and the State Historic Preservation Officer as well as the Mining Supervisor.

CHAPTER 13

SUBSIDENCE CONTROL

13.1 SUBSIDENCE CONTROL

There is a possibility of subsidence of the surface over the retorted area at some time after a burn. However, accurate predictions of subsidence will be possible only after several retorts of the Modular Development Phase have been burned and the results observed. It is not currently known if the height of the rubblized oil shale within the retort will shrink during retorting. This possibility is suggested by work done by the Laramie Energy Research Center of ERDA. Assuming shrinkage of a commercial retort interval of 70 to 100 feet out of a total of 750 feet, failure of several lines of pillars would assure surface subsidence. Therefore, the actual extent to which the height of the rubblized shale within the retort shrinks will be carefully measured in one or more of the retorts burned during the Modular Development Phase (MDP). Experience gained in that work will form the basis for accurate predictions of subsidence, if any, to be anticipated in the Commercial Phase.

The fact that the roof of an underground opening fails does not necessarily mean the failure will progress until the surface subsides. The surface may uniformly subside a few inches or a few feet and not be noticeable or present any hazard. On Tract C-a, surface subsidence is more likely in areas of relatively shallow overburden rather than where the deposit is more deeply buried. Such shallow overburden areas include those where the stream beds cross the mine area. Although these streams flow only intermittently, subsidence could present a hazard in an area such as Corral Gulch where one of the rare flash floods could reach a severely subsided area and flood the underground mine. The methods for prevention or mitigation are outlined in 13.3.

Thickness and temperature of underground pillars are important considerations relating to potential subsidence. The pillar widths for the several "fields" of the mine will be varied, with thicker pillars in areas of thicker overburden. These pillars are sufficiently strong to hold up the overlying rock at ambient temperatures. However, if the temperature of the interior of a pillar should rise, the pillar would weaken and might not be able to support the overlying load. Although it is not currently possible to predict the timing or effect of temperature on pillar strength, data will become available during the MDP. The rate of temperature rise within the pillars will be especially important. Some investigators have contended that the heat conductance of oil shale is so low that the temperature of the interior of the pillars will never rise appreciably. It may be desirable to cool the retort with water upon the completion of the burn to suppress pillar temperature rise.

13.2 SUBSIDENCE MONITORING

A survey monument grid will be placed on the ground surface over the MDP retort area prior to its rubblization. The coordinates and elevation of each of the monuments will be recorded. RBOSP will determine the horizontal and vertical relationship of these monuments to a benchmark sufficiently distant from the retorts to assure that the benchmark does not itself undergo any horizontal or vertical displacement. Topographic maps at 1" = 200' and a 5-foot contour interval are currently available for the retort area. These will serve as a base for preparation of larger scale maps at a one-foot contour interval of the local area above the MDP retorts.

During and after the completion of the burn, the position of the monuments of the grid will be read periodically. When it becomes apparent that detectable disruption of the surface has taken place, the topography of the surface will be re-mapped to establish the pattern of subsidence.

During the burn of the retorts of the MDP, RBOSP will quantify surface subsidence; the emphasis will be on detecting and quantifying it. Maintenance of pillar integrity or the load-carrying ability of the retorted rubblized shale will be depended on to prevent subsidence. The behavior of these MDP retorts after the burn will be carefully observed to serve as an indicator of what can be expected from the Commercial Phase retorts. The top of some of the MDP retorts will be re-entered if possible, to quantify shrinkage of the rubble zone.

Because subsidence tends to be a long-term effect, the fact that no ground displacement is observed above a retort several years after it has been burned does not assure that the surface will never subside. For this reason, subsurface monitoring of the rock integrity above the most subsidence-prone MDP retorts will be performed. This will be done either by borehole instruments, access drifts or seismic methods. The behavior of the retort roof after the burn will be progressively observed by the methods found to be the most effective.

The monitoring of subsidence over the Commercial Phase retorts will consist solely of the placement of monument grid over each retort to record vertical and horizontal displacements at appropriate intervals. This practice may be discontinued if mitigative measures prove to be uniformly successful.

13.3 SUBSIDENCE MITIGATION

If the MDP shows that surface subsidence will be sufficiently severe to warrant mitigative measures, two broad approaches will be considered. The first would be to backfill the burned out retort; the second would be to allow the surface to subside and apply appropriate rehabilitation measures.

In applying the backfill method, one approach would be to mix a water slurry of spent shale or finely ground raw shale at about 48 weight

percent solids and introduce it into the retort after the completion of the burn. Preliminary tests conducted by Amoco Research and work currently underway by Denver Research Institute indicate the likelihood of being able to permeate the mass of burned rubblized shale and drain it of excess water to produce an aggregate with considerable compressive strength. Drill holes through the spent rubbled shale would convey the slurry to the bottom of the retort where it would be pumped into the rubble under pressure. As the bottom of the retort fills, the delivery pipe would be raised and delivery at successively higher elevations continued until the entire rubble zone is permeated. Porous stoppings at the bottom of the retort would prevent the slurry from flowing into the mine and would also serve as a filter to allow excess water to escape. The injection holes through the rubblized interval could be drilled from the surface or from the attic drift. Experiments along these lines during the MDP will serve to verify the feasibility of this approach. Permeation of the entire mass of rubblized processed shale with a slurry would serve the dual purpose of strengthening the rubble sufficiently to allow it to support the overlying rock and rendering it impermeable to groundwater as discussed in Section 6, Chapter 14, Abandonment.

If surface subsidence occurs during MDP and prevention by slurry filling is not feasible, consideration will be given to dry filling the attic space of the retort with either processed shale from surface retorts or raw shale produced in mining the void volume of developing retorts. This would result in filling only a part of the attic void above the burned retort. However, it is conceivable that this will be sufficient to prevent the progressive failure of the overlying strata from reaching the surface. Dry filling could be accomplished from the attic drift. A boom stacker developed for underground use or some variety of belt slinger could be utilized. The feasibility of attic drift dry filling, including safety considerations, can only be evaluated during the MDP.

If occasional pits and fissures occur in the surface which could present a hazard to personnel, livestock or wildlife, such openings could be filled from the surface and revegetated. Revegetation experiments both on Tract C-a and elsewhere are yielding information on methods for restoring vegetative cover on processed shale embankments.

It is conceivable that the surface may subside uniformly without appreciable disruption. In this event, the surface would retain its original value as grazing land or wildlife habitat without any mitigative action.

A broad enough spectrum of mitigative measures are available to offset the adverse effects of disruptive subsidence, should it occur. The area of the MDP retorts will be the first developed and hence the first in which the subsidence problem can be observed and directly assessed. Therefore, appropriate mitigative measures will be designed after RBOSP's experience with the MDP.

CHAPTER 14

ABANDONMENT

CHAPTER 14
ABANDONMENT

Disposition of project facilities when operations cease will be influenced by a number of considerations, including:

- Profitability of oil shale operations.
- State of the art in oil shale retorting.
- Usefulness of the facilities to adjacent operations.
- Degree of government participation and/or control in the shale oil industry.
- Degree of project development.

Because of the wide variety of possible abandonment schemes, it is not possible to propose a definite plan of action at this time. RBOSP recognizes the requirement of submitting an abandonment plan which would be subject to AOSS approval prior to abandoning the lease. Initially a showing of compliance with the terms of the lease by RBOSP would be submitted to the AOSS, and, upon its acceptance, a notice of relinquishment would be filed as provided in Section 28 of the lease. Buildings and equipment on the lease would be sold to the government at appraised value or removed by RBOSP, at government option, as prescribed in Section 32 of the lease.

The guidelines of this chapter will be used to prepare detailed abandonment plans and procedures prior to abandonment activities. Of course, if the facilities should be sold by RBOSP as an operating facility, the demolition, salvage and rehabilitation activities would not take place. Also, for a period of six months after termination of the lease, the lessor has the right to purchase, at the appraised value, any or all items on the lease required or useful for the protection of the leased lands.

Design of the abandonment activities will be governed by the various environmental protection plan concepts. The objective will be to return the site to a stable ecological state that will not contribute to continuing environmental deterioration and that will be consistent with the appearance of the surrounding area. All required monitoring programs will continue until the AOSS has determined to his satisfaction that environmental conditions which are consistent with the requirements of applicable Federal and State statutes and regulations have been established; however, the AOSS may terminate this requirement at an earlier date when it is in the public interest.

14.1 MINE AND UNDERGROUND RETORTS

A. Modular Development Phase (MDP) - Abandonment of the mine and burned retorts is not anticipated during this developmental phase of operations. However, since adverse economic, technical, environmental or governmental factors could require a shutdown of the Modified In Situ operation, consideration has been given to an abandonment plan. If cessation becomes necessary, a more detailed abandonment and rehabilitation plan will be submitted for approval at that time.

The MDP encompasses at least six retorts, the first five of which are less than full commercial size. During the interval of the MDP prior to the election of abandonment, a study of the effect of the burned retort on groundwater quality will have been made. This can best be accomplished by passing water through the spent retort and observing the quality of the effluent. The method of mitigation of degradation of groundwater quality will be selected, based on the results of this study and knowledge of groundwater quality and migration velocity.

Among possible methods of mitigation of degradation of groundwater quality from spent retorts are the following:

- Backfilling the spent retort with a water slurry of some appropriate material.

- Water flushing the spent retort to leach soluble salts with subsequent surface treatment of the leachate.
- The isolation of the spent retorts from groundwater aquifers by cement or chemical grout curtains.
- No mitigating action should it be found that spent retorts do not materially affect groundwater quality.

The question of subsidence has been treated in Chapter 13 and measures found necessary to prevent or mitigate subsidence will be taken at the time of abandonment. It is less probable that surface subsidence will occur if the MDP is not completed than if some appreciable number of commercial retorts have been burned.

Beyond the question of subsidence, underground openings would be sealed so as not to present a hazard or an attractive nuisance as required by Colorado Mining Regulations. The surface would be appropriately contoured and revegetated as necessary.

B. Commercial Phase - Portions of the commercial mine will be abandoned as they become exhausted. This does not rule out the eventual possibility of development and implementation of methods of secondary recovery of oil from pillars. Eventually the lease tract will be exhausted of mineral values. Abandonment may be elected prior to this time because of adverse economic, technical, environmental or governmental factors.

The protection of groundwater aquifers from possible contamination from spent retorts is an important consideration in abandonment plans. The most effective method or combination of methods found during the MDP for the protection of groundwater quality will be implemented during the Commercial Phase as retorts are progressively abandoned. In this way, usable water in the aquifers will be protected. The actual method used could be one of the four listed in the MDP discussion above, or it may be a better method developed during the MDP.

The problem of surface subsidence has been treated in Chapter 13. The subsidence problem, if any, and the most effective mitigative procedures will be more clearly understood after a number of years of operation than it is today. Such measures necessary to restore the surface for wildlife habitat, will be taken. Shafts and boreholes will be sealed and abandoned so as not to present a hazard to either humans, livestock or wildlife.

14.2 PROCESSING FACILITY

Abandonment of the processing facility will involve several stages.

- All tanks, aboveground structures and aboveground piping will be salvaged and removed. Minimum maintenance shops and administration facilities will remain in place until the final stages of abandonment near completion.
- All concrete structures will be demolished down to grade level, and all concrete and asphalt surfacing, curbs, etc., will be broken up in place. Hard packed, unsurfaced or temporarily surfaced roads will be scarified and the tight surface broken up.
- Underground piping, culverts and drains will be plugged and abandoned in place. After the connection pipes have been plugged, catch basins and manholes will be filled with earth.
- All concrete foundations, pavements and other manmade features reduced to rubble at grade will be covered with earth. Most of the cover material can be salvaged from dikes and fill areas or, if necessary, excavated within the already-disturbed areas.
- All graded areas will be recontoured through slope rounding, cutting, filling and other earthwork similar to the techniques discussed in Chapter 8. Dikes will be removed, ponds and ditches filled or reshaped, and the land generally restored to a natural appearance. The area will then be revegetated in accordance with the principles established for revegetation in

Chapter 8. All these activities will be designed to rehabilitate all affected land to a usable and productive condition consistent with or equal to pre-existing land uses in the area and compatible with existing, adjacent undisturbed areas.

14.3 PROCESSED SHALE AND DEVELOPMENT ORE DISPOSAL SITES

Abandonment of this area will require little more than completion of the rehabilitation-revegetation activities that will be continuing throughout the life of the project. Final abandonment activities will include:

- Completion of revegetation and removal of irrigation facilities and temporary fencing.
- Obliteration of access roads (roads which will not be left for public use) and revegetation of the last remaining disturbed areas.
- Reshaping and revegetation of any abandoned ponds, ditches or dikes.
- Creation of a condition not requiring further maintenance.

The Commercial Phase operation envisions the use of conveyors to transport the waste material to the disposal site. The first stage of abandonment in the Commercial Phase will be the dismantling, salvage and removal of these conveyors. Reshaping and revegetation of service roads and conveyor routes will proceed simultaneously with the final revegetation activities on the disposal site.

14.4 SUPPORT FACILITIES

Abandonment of support facilities will follow the same stages as discussed for the processing facility. If desired, some features such as the following may be left in place for other uses:

- Clean-water impoundments.
- Selected roadways.
- Selected pipelines and power lines.

Determination of the facilities to remain, if any, will be made at the outset of detailed planning of the abandonment activities to ensure that some desired facility is not inadvertently destroyed.

Historically, the reclamation efforts for the water control facilities have utilized small check dams in larger water control ditches to prevent further erosion and to partially repair existing damage by allowing the area behind these check dams to silt in. These practices will probably be adopted for abandonment of Tract C-a facilities.

The future abandonment plans for Tract C-a shall include the filling and packing of any ditches and the leveling of water diversion dikes associated with oil shale activities which do not contain check dams or other flow inhibitors. The filling of these ditches and leveling of dikes will result in a great reduction, if not elimination, of gully erosion. Existing reservoirs remaining after abandonment will be allowed to silt in and will serve as a control against high flow in the area.

Water quality control ponds such as those downstream from the processed shale disposal site will be allowed to silt in. In the event that a high concentration of soluble salts exist in the ponds, a disposal or protection plan will be developed for approval by the AOSS. A second alternative would be to release the reservoir to the proper Federal administrative agency. After the proper Federal agency has assumed administration of the reservoir, it may develop a plan for the best use at that time.

SECTION 6

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LITERATURE CITED

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SECTION 7

ENVIRONMENTAL ASSESSMENT

CHAPTER 1
INTRODUCTION

Oil shale development on Tract C-a will affect the air quality, terrestrial and aquatic ecology, surface and sub-surface waters, and cultural resources of the area. Impacts from the planned development of oil shale on Tract C-a were assessed to determine the effects, both beneficial and harmful, of development on the environment. Means of lessening or mitigating harmful impacts were suggested.

Impacts were assessed by identifying and quantifying (to the greatest degree possible) all development actions which could potentially cause impacts to the environment and by subsequently identifying all environmental factors which would be subject to these impacts. A cause-effect matrix (Leopold et al., 1971) was used to systematically identify all possible impacts.

Fifty proposed actions were plotted against 73 environmental factors that could be affected (Table 7-1-1). Two rankings from 1 to 5 were assigned to each impact at the intersection of each action and environmental factor (Figure 7-1-1). The first rank describes the importance of the proposed impact; the second rank describes the severity or magnitude of the impact. Increasing values represent increasing importance or severity. The modular development of Tract C-a will result in various degrees of impact. For this reason the matrix analysis was performed twice - once for the Modular Development Phase and again for the Commercial Phase. Areas of disturbance for each of the phases are shown in Figures 7-1-2 and 7-1-3. A typical completed portion of the Commercial Phase cause-effect matrix is shown in Figure 7-1-1.

Action were described on the basis of Tract C-a development plans and after many consultations with RBOSP mining and processing specialists.

Table 7-1-1

PROPOSED ACTIONS AND POTENTIALLY AFFECTED PARAMETERS
WHICH WERE ANALYZED ON THE "CAUSE-EFFECT" MATRIX

Actions

Construction:

- Mine surface facilities
- Surface Retorts
- Underground retorts
- Support facilities
- Powerlines
- Pipelines
- Conveyor belts
- Impoundments
- Roads
- Steam Generator
- Compressors
- Evaporation ponds, catchment basins
- Dewatering Network
- Cumulative Construction

Operations:

- Mine ventilation
- Blasting
- Dewatering/reinjection
- Underground retorting
- Surface retorting
- Compressing
- Emissions

Manpower:

Storage and Transfer:

- Run-of-mine ore
- Construction Materials
- Oil, gas, diesel fuel
- Chemicals
- Machinery
- Explosives
- Feedstocks
- Soil
- By-products/waste
- Product oil

Environmental Parameters

Atmospheric:

- Precipitation chemistry
- Particulate concentrations
- Gaseous concentrations
- Ozone levels
- Temperature
- Relative humidity
- Visibility
- Noise levels

Groundwater:

- Quantity
- Quality
- Flow, Movement
- Recharge/discharge
- Level
- Availability/Consumption

Surface Water:

- Quantity
- Quality
- Flow, velocity
- Drainage basin characteristics
- Sediment load
- Temperature
- Stream bed
- Springs and seeps
- Sediment chemistry

Soils:

- Erosion potential
- Physical characteristics
- Chemical characteristics
- Trace metals

Topography:

- Slope aspect
- Drainage patterns
- Terrain stability

Table 7-1-1 (Continued)

Disposal:

- Processed shale
- Product, Mine seepage water
- Sewage
- Trash, wastes
- By-products
- Cumulative disposal actions

Subsidence:

Abandonment:

Environmental Monitoring:

- Atmospheric sampling
- Groundwater Monitoring
- Surface water Monitoring
- Aquatic biota sampling
- Vegetation sampling
- Faunal sampling
- Soils studies

Environmental Mitigation:

- Subsidence Control
- Habitat enhancement
- Revegetation

Vegetation:

- Productivity
- Range condition
- Community composition
- Distribution
- Trace Metal Content
- Cover, density
- Browse Condition

Small Mammals:

- Relative abundance
- Species composition
- Distribution

Large Mammals:

- Relative abundance
- Distribution
- Migration patterns

Predatory Mammals:

- Relative abundance
- Species composition
- Distribution

Reptiles and Amphibians:

- Relative abundance
- Species composition
- Distribution

Avifauna:

- Relative Abundance
- Species composition
- Distribution
- Migration patterns

Invertebrates:

- Relative abundance
- Species composition
- Distribution

Table 7-1-1 (Continued)

Plankton:

- Relative abundance
- Species diversity
- Habitat
- Productivity

Periphyton:

- Relative abundance
- Species diversity
- Habitat
- Productivity

Benthos:

- Relative abundance
- Species diversity
- Habitat

Fishes:

- Relative abundance
- Species diversity
- Distribution
- Food habitats
- Condition
- Habitat

Figure 7-1-1

A REPRESENTATIVE PORTION OF THE COMMERCIAL STAGE "CAUSE-EFFECT" MATRIX PERFORMED FOR RBOSP OIL SHALE DEVELOPMENT

Affected Factor	CONSTRUCTION Mine	Surface Retorts	Underground Retorts	Support Facilities	Conveyor Belts	Impoundments	Roads	Compressors	Disposal Pile	Cumulative Construction
VEGETATION										
Productivity	1/2	2/2	1/1	1/2	1/2	1/2	1/2	1/2	3/3	3/3
Range Condition	1/2	1/2	1/1	1/2	1/2	1/2	1/2	1/2	2/3	2/3
Community Composition	1/2	2/2	1/1	1/2	1/2	1/2	1/2	1/2	3/3	3/3
Distribution	1/2	2/2	1/1	1/2	1/2	1/2	1/2	1/2	3/3	3/4
Trace Metal Content	1/1	1/1	1/1	1/2	1/1	1/1	1/1	1/1	1/1	1/1
Cover Density	1/2	2/2	1/1	1/1	1/2	1/2	1/2	1/2	3/3	3/4
Browse Condition	1/2	2/2	1/1	1/2	1/2	1/2	1/2	1/2	3/3	3/3

Ranking were defined as follows:

Importance
1-None, not applicable
2-Slightly important
3-Moderately important
4-Very important
5-Extremely important

Severity/Magnitude
1-None, not applicable
2-Slightly severe small
3-Moderately severe, medium
4-Very severe, large
5-Extremely severe, quite large

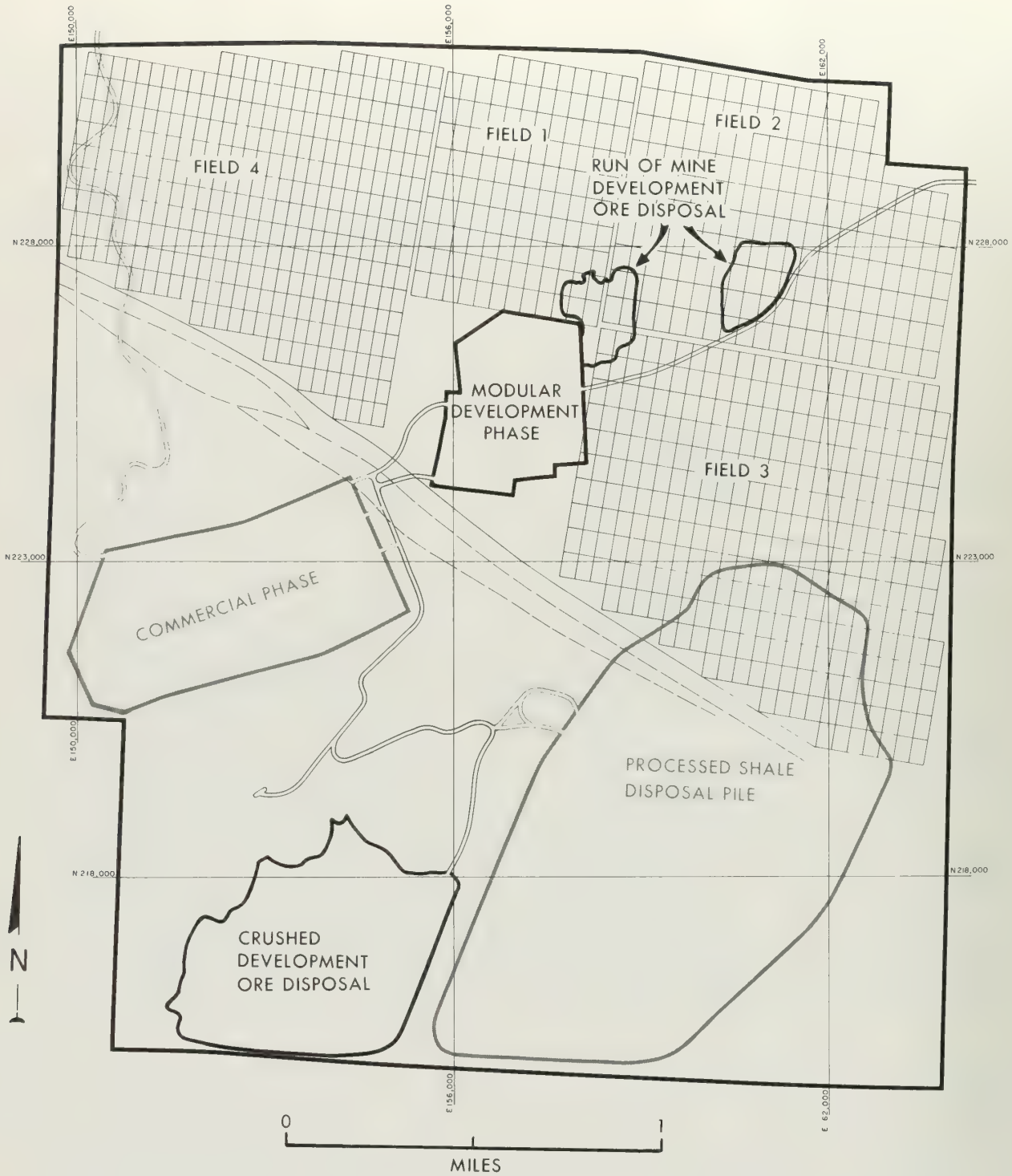

Figure 7-1-2
LOCATION OF MODULAR DEVELOPMENT PHASE FACILITIES

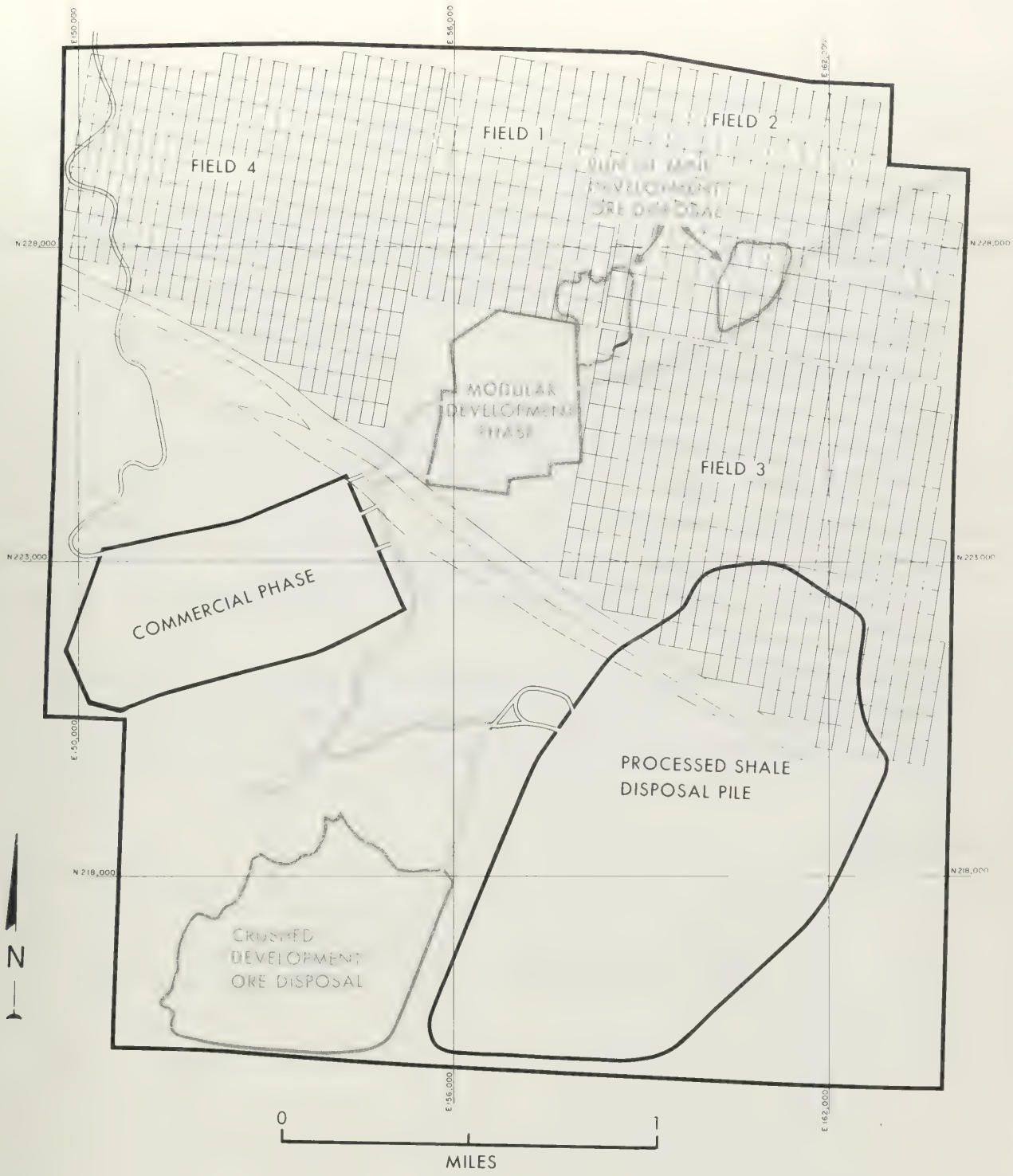

Figure 7-1-3
LOCATION OF COMMERCIAL DEVELOPMENT PHASE FACILITIES

Environmental factors that could potentially be affected were identified by a group of environmental specialists. Proposed actions were assigned to one of the following arbitrary categories: construction, mining operations, processing operations, power generation, manpower, storage and transfer, disposal, subsidence, decommissioning and abandonment, environmental monitoring, and environmental mitigation. Each action category was further divided into specific development actions for greater resolution of impact.

Environmental categories included the atmosphere, groundwater, surface water, soils, topography, vegetation, birds, small mammals, large mammals, predatory mammals, reptiles and amphibians, invertebrates, plankton, periphyton, benthos, and fish. Specific factors likely to be affected (e.g. productivity) were listed for each environmental category.

Identification and listing of these items on the matrix was followed by quantification of potential impacts through the ranking process, as shown on Figure 7-1-1. The following guidelines were used in ranking:

Importance

- Short term impacts ranked 2 or 3; long-term impacts 4 or 5.
- Impacts to rare or endangered species ranked 4 or 5.
- Multicomponent impacts ranked 4 or 5; single component impacts 2 or 3.
- Impacts of high public concern ranked 3 or 4; those of lesser public concern only 2.
- Impacts to human health ranked 4 or 5; others should rank lower.
- Impacts of major economic importance ranked 4 or 5.

Severity/Magnitude

- Localized impacts ranked 2 or 3.
- Cumulative impacts (over time) ranked 4 or 5; non-cumulative 2 or 3.

Areas of ecological sensitivity, vulnerability, or importance were given special attention.

The judgements of a large number of specialists, including atmospheric scientists, hydrologists, aquatic and terrestrial biologists, and geologists, were considered in assigning rank. Each member of the assessment team was thoroughly versed in the project background, development plans, and baseline conditions on Tract C-a. All assumptions and/or justifications for value assignments were noted during the ranking process. Once the assignment of values was complete, the matrix and accompanying assumptions and justifications were routed to each team member for review and comment. Comments were also elicited from RBOSP personnel. Final impact rankings were based on an in-depth analysis and review of baseline data and finalization of the development plans.

In addition to its use in assessing impacts, the cause-effect matrix was used in combination with two other matrix analyses to select monitoring parameters and to devise a monitoring program. Details are given in Section 8 - Environmental Monitoring.

The advantages of such a regimented approach were:

- Consideration of all areas potentially affected.
- Effective detection of gaps or missing information.
- Qualification of sources of impacts early in the assessment process.
- Comparison of impacts between disciplines.

Once assessments of potential impacts had been completed through the matrix analysis, mitigation measures were formulated. This process required close coordination between environmental specialists and RBOSP engineers. Mitigation measures were formulated to reduce the net impact to the environment. In many cases formulation of mitigation measures necessitated reevaluation of the importance-severity ranking. The final

matrix values (available in their entirety from AOSO) assume that certain impacts will be mitigated.

Matrix analysis indicated that modular impacts will generally be less severe than commercial impacts. This is largely a function of the extent and duration of planned activities.

Of all potentially impacted areas, ground and surface water hydrology ranked highest. Actions judged to be potentially important to the hydrological system (3/3 or higher) included construction of underground retorts, dewatering/reinjection, and disposal of product and mine seepage water. The impacts predicted for these actions are discussed in Chapter 6 of this section.

Impacts on vegetation and fauna will be limited to Tract C-a and the immediate vicinity. Habitat loss will result from disposal pile construction, cumulative construction disturbance, processed shale disposal, and cumulative disposal actions. As a result of habitat loss, forage and browse availability will be affected. Habitat modification and revegetation will provide positive impacts. During Modular and Commercial Phases, mule deer distribution and migration will be disturbed because of construction and by habitat modification.

Impacts to soils were ranked 3/3 or higher for disposal pile construction (erosion), cumulative construction disturbance, dewatering (addition of trace metals), processed shale disposal, and cumulative disposal.

Several atmospheric characteristics, including particulates, gaseous concentrations, visibility, and noise, were considered likely to be impacted by various development actions, including construction disturbance, emissions, and cooling tower drift. Impact rankings assigned to aquatic biota were significant only for periphyton, and benthos. These impact rankings reflect projected erosion and siltation during construction, dewatering, and sampling disturbances. The creation of new

aquatic habitat by the construction of sewage lagoons and containment ponds will be beneficial impact.

Creation of underground voids caused by the burning of retorts and removal of oil, gas and water may create a potential subsidence hazard. RBOSP is currently investigating methods by which subsidence can be avoided or greatly reduced. Should these methods prove practical, impacts will be minimal. If subsidence should occur in localized areas, surface voids will be filled with rock and revegetated to prevent impacts on surface drainages and aesthetics.

The following chapters contain detailed descriptions of the sources of impacts during the two phases of development, the measures that will be employed to minimize or prevent them, and the net impact after mitigation. The cause-effect matrix was used to classify impacts by importance and severity. Discussions of impacts in this chapter include high ranking impacts as well as some that are important for other reasons (e.g., public concern).

The net impact of Tract C-a oil shale development as discussed in this revised DDP to the region is extremely low. Impacts will be confined almost exclusively to on-tract lands.

CHAPTER 2

ENVIRONMENTAL SETTING AND WILDLIFE INVENTORY

The physical and biological components of Tract C-a and vicinity have been thoroughly studied and described during 2 years of extensive baseline studies. Reports have been published on a quarterly and annual basis during this period. Complete descriptions of Tract C-a topography and geology appear in RBOSP Progress Report 5. Discussions of Tract C-a hydrology, atmospheric conditions, aquatic ecology, terrestrial ecology and cultural resources can be found in the "Final Environmental Baseline Report for Tract C-a and Vicinity" (RBOSP, 1977) and RBOSP Progress Report 10 (1977).

This chapter presents a summary of the physical characteristics and environmental setting of Tract C-a and vicinity as required by the Code of Federal Regulations 30 CFR 231.10 C (2).

2.1 TOPOGRAPHY AND GEOLOGY

A. General Location of Project Area - Tract C-a is located in northwest Colorado, about midway and slightly south of a line between Denver and Salt Lake City. More specifically, the tract lies in the western third of Rio Blanco County, about 20 airline miles southeast of Rangely, 35 miles southwest of Meeker and some 75 miles due north of Grand Junction. The location of Tract C-a is illustrated in Figures 7-2-1 and 7-2-2.

The specific lands covered by the Tract C-a lease encompass about 5,100 acres and are legally described as:

T. 1 S., R. 99 W., 6th P.M.
Sec. 32: E1/2, E1/2W1/2

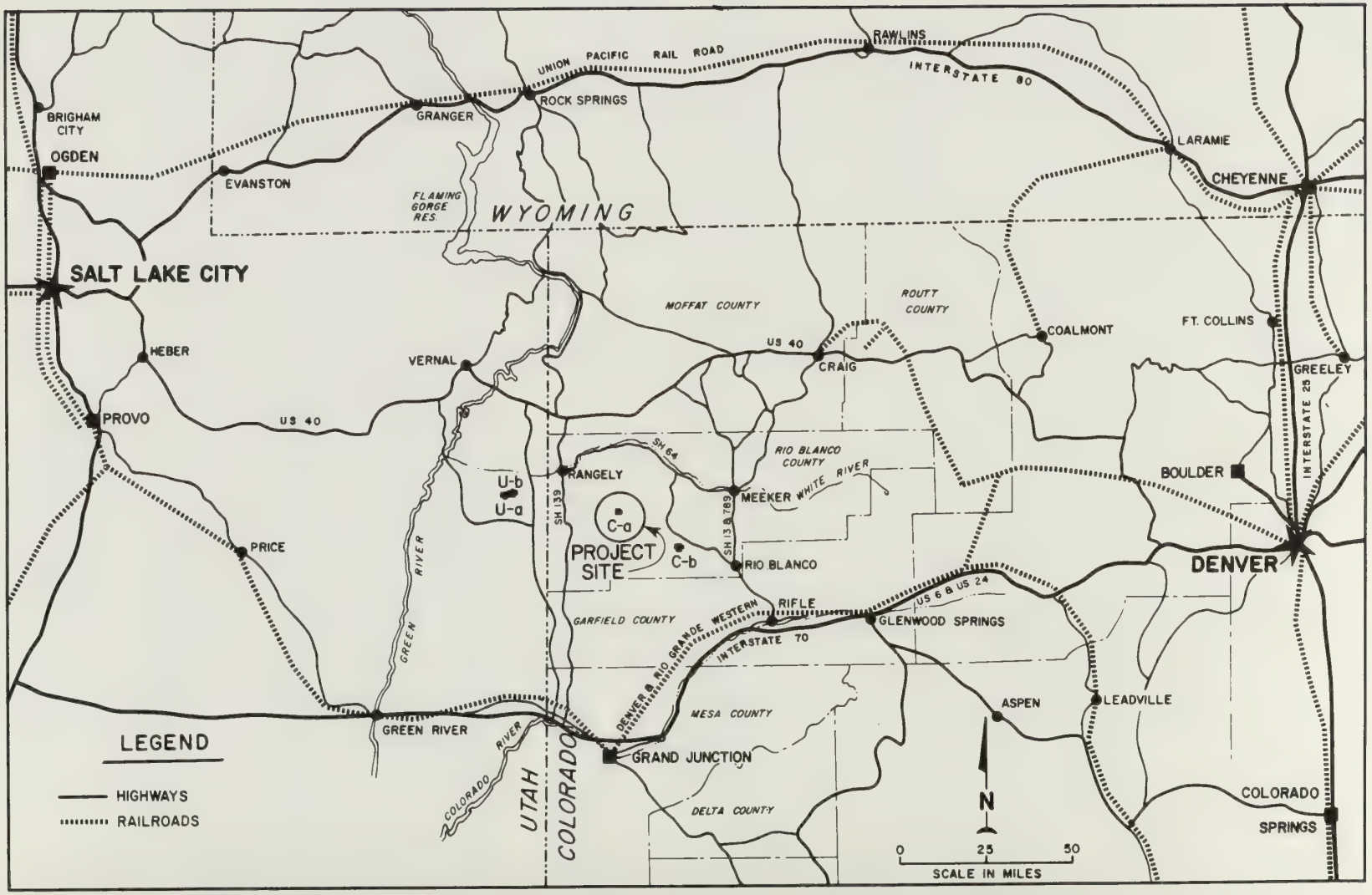

Figure 7-2-1

REGIONAL MAP SHOWING LOCATION OF TRACT C-a

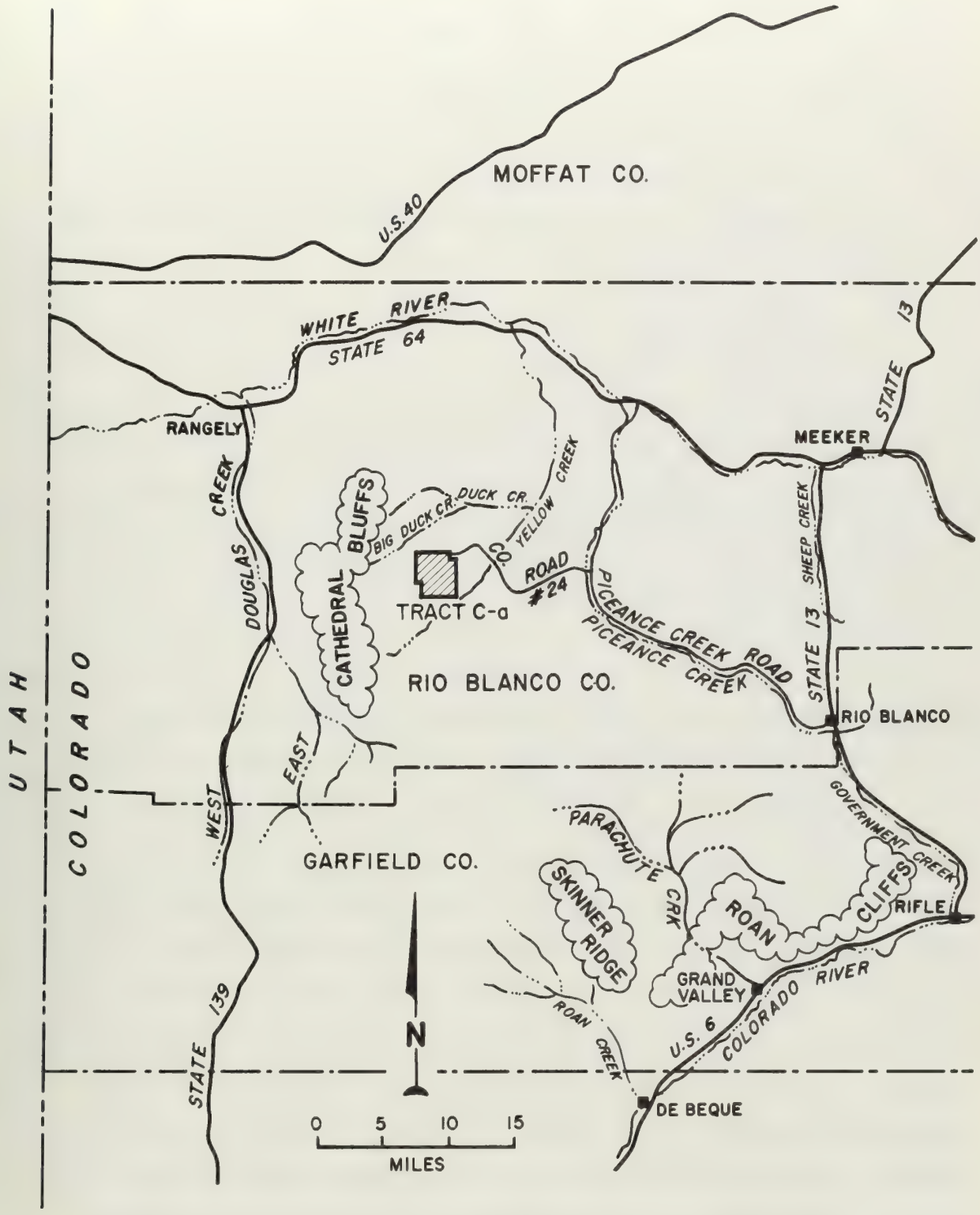

Figure 7-2-2
LOCATION MAP OF TRACT C-a

Sec. 33: All
Sec. 34: W1/2, SE1/4, W1/2NE1/4, SE1/4NE1/4

T 2 S., R. 99 W., 6th P.M.
Sec. 3: All
Sec. 4: All
Sec. 5: E1/2, E1/2W1/2 (incl. Lots 1, 2 and 3)
Sec. 8: E1/2
Sec. 9: All
Sec. 10: All

B. Topography and Cultural Features - Tract C-a is situated on the west flank of the Piceance Creek basin about 5 miles east of the Cathedral Bluffs. The term, "Piceance Creek basin", as used here refers to an area of approximately 1,600 square miles that is bounded on the north by the White River, on the east by Government and Sheep Creeks, on the south by the Colorado River and Roan Creek, and on the west by Douglas Creek.

Physiographically, the Piceance Creek basin is part of the Colorado Plateau province. Because the basin was subjected to extreme vertical uplift in relatively recent geologic time, it now appears, in relief, as a large shallow bowl lying atop the Roan Plateau. The edges of the basin lie near the rim of the plateau and, as a result, streams draining the exterior faces of the plateau are short, few in number, and have steep gradients. Piceance and Yellow Creeks and their tributaries, which drain the basin proper, are longer and more gently sloping.

The basin's topography is characterized mainly by a series of nearly parallel north and northeasterly trending ridges and valleys. Local elevation differences range from 200 to 600 feet. Piceance Creek, Yellow Creek, and tributaries of Douglas and Sheep Creeks drain the northern part of the oil shale area and are tributaries of the White River. Parachute Creek, Government Creek and Roan Creek drain the southern part of the oil shale area and empty into the Colorado River.

Slopes of northern canyon walls are typically steeper than southern walls. Valley floors are narrow and ridges are broad and rounded; both slope gently northeastward. Surface elevations vary from about 6600 feet in Corral Gulch near the northeast corner of the tract to slightly more than 7400 feet on Airplane Ridge near the southwest corner of the tract. The average elevation difference between valley floors and nearby ridge tops is about 300 feet. The valleys and ridges crossing Tract C-a originate to the southwest in the vicinity of Cathedral Bluffs which rise to elevations varying between 8400 and 8700 feet. Most of Tract C-a is drained by Corral and Box Elder Gulches, which join just east of the tract and eventually join Stake Springs Draw about 3.5 miles east of the tract to form Yellow Creek.

Yellow Creek flows northeast from its origin but eventually curves to the northwest before emptying into the White River about 20 miles north of Tract C-a at an elevation of some 5500 feet.

The first principal drainage north of Tract C-a is Big Duck Creek which flows into Yellow Creek about 7 miles northeast of the tract. On the south, Ryan Gulch passes within about 2.5 miles of the southern boundary of Tract C-a before meeting Piceance Creek about 10 miles due east of the tract, where the elevation is about 6100 feet.

Few man-made features occur on or in the vicinity of Tract C-a. The old Shields-Caldwell Hunting Camp near the confluence of Corral Gulch and Dry Fork is located on the tract. In 1975, RBOSP built a small reception center in the extreme northeast corner of the tract. The only occupied dwellings in the area are at the Reagle Ranch headquarters on Ryan Gulch about 3 miles southeast of the tract.

Elsewhere in the vicinity of Tract C-a, the area is interspersed with primitive roads and trails; a gas pipeline crosses the southeast corner of the tract, then parallels Stake Springs Draw for several miles before crossing the Cathedral Bluffs; a power transmission line some 5 miles west of the tract; several miles of fence at various locations; and

several improved springs, check dams and small reservoirs. The nearest improved road is Rio Blanco County Road 24 which leads into the northeast corner of Tract C-a. The only paved highways in the vicinity are the Piceance Creek road to the east, the Douglas Pass road (State Highway 139) to the west, and State Highway 64 between Rangely and Meeker to the north. There are also several conventional natural gas wells scattered throughout the area southeast of Tract C-a. Topography and cultural features on and around Tract C-a are further illustrated on Figure 7-2-3.

C. Geology - The geology of Tract C-a was defined with new aerial photography, photogeologic mapping, surface geologic mapping, core hole drilling, laboratory analyses and data compilation. This provided the structural, stratigraphic, and resource data necessary for detailed engineering and formulation of the Detailed Development Plan.

1. Stratigraphy - Only the stratigraphic intervals pertaining to tract development, namely, the oil shale-bearing Green River Formation and the overlying Uinta Formation, are discussed below.

The oil shale underlying Tract C-a was deposited in the eastern portion of ancient Lake Uinta during Eocene time. The term "oil shale" is actually a lithologic misnomer because the rock is not shale nor does it contain oil in the conventional sense. Most oil shale is dolomitic marlstone containing variable amounts of organic matter (kerogen) derived chiefly from algae, aquatic organisms, waxy spores and pollen grains. This organic matter is only slightly soluble in ordinary petroleum solvents, but a large part can be converted to synthetic oil by destructive distillation.

Figure 7-2-4 is a generalized stratigraphic column of Eocene rocks in the Piceance Creek basin showing the relative stratigraphic position of the major Eocene units, the interval containing oil shale and several key stratigraphic markers. Several of the key stratigraphic markers provide convenient boundaries which segregate major lithologic units

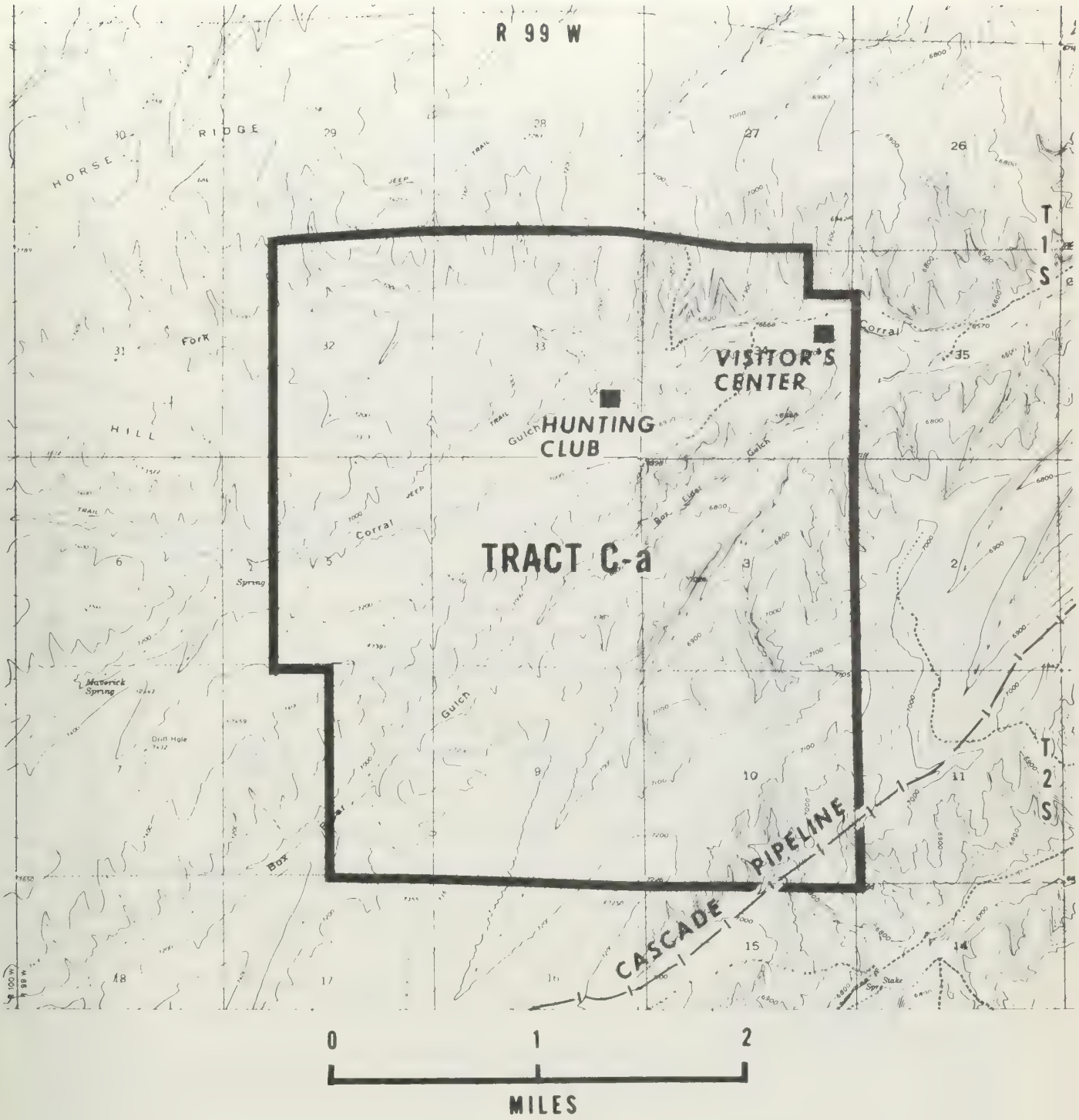

Figure 7-2-3
TOPOGRAPHY & CULTURAL FEATURES

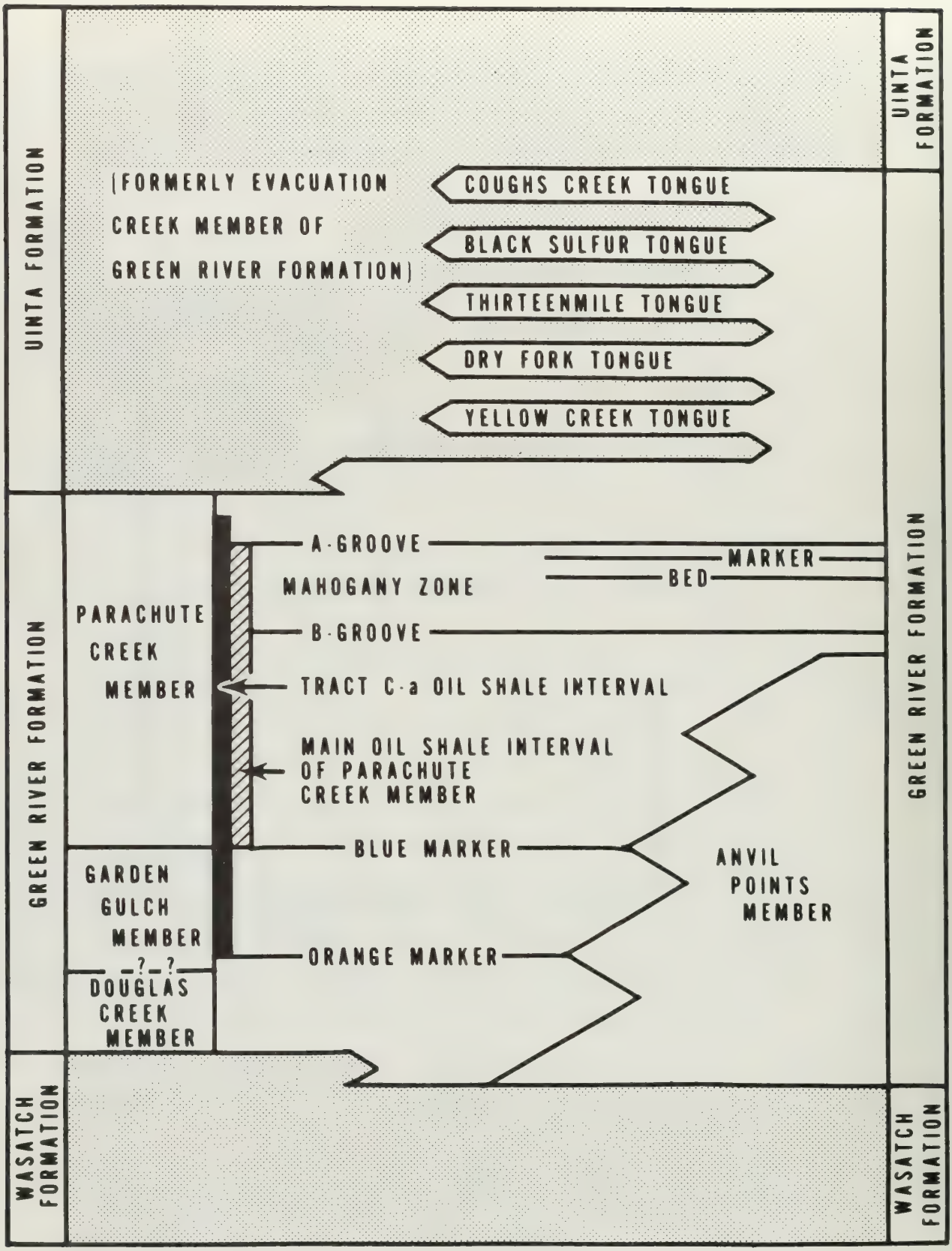

Figure 7-2-4

GENERALIZED STRATIGRAPHIC COLUMN OF TERTIARY EOCENE SERIES,
PICEANCE CREEK BASIN

within Tract C-a. The Orange marker to Blue marker is the uppermost part of the Douglas Creek-Garden Gulch Members (undifferentiated) and consists mainly of light gray to brownish gray oil shale with lesser amounts of gray shaley siltstone. The overlying interval from the Blue marker to A-groove is the main oil shale interval of the lower Parachute Creek Member, Green River Formation, which consists mainly of dolomitic marlstone with varying amounts of kerogen. The upper part of the Parachute Creek Member above the A-groove is mainly light gray to medium brown oil shale grading upward into light gray barren marlstone interbedded with gray siltstone and fine-grained sandstone. The overlying Uinta Formation covers most of the tract's surface and consists mostly of brown to light brown fine-grained massive sandstones with lesser amounts of siltstone.

Based on a subsurface correlation network, an oil shale zonation was established within Tract C-a. This zonation resulted in the delineation of 19 zones, 9 relatively rich and 10 relatively lean. Figure 7-2-5 is a core hole histogram cross section of Tract C-a showing the alternating rich (R-O through Mahogany and R-8) and lean zones (L-OO through L-8).

Acid-extractable alumina is present in all 19 rich and lean oil shale zones. USBM x-ray diffraction analyses of core samples show that dawsonite and nordstrandite occur in a stratigraphic interval from the upper part of the R-2 zone through the lower part of the R-5 zone. Analcime occurs stratigraphically above and below the dawsonite-bearing interval.

Within Tract C-a, limited amounts of nahcolite occur as thin beds, stringers, nodules and coatings or small crystal growths on both vug walls and shale partings. The few scattered beds are usually less than 1-foot thick with a maximum thickness of 2 feet. Primary deposition of nahcolite within Tract C-a was apparently limited to nodules and a few relatively thin beds and stringers. Subsequent removal of the water-soluble nahcolite by groundwater leaching has reduced its original

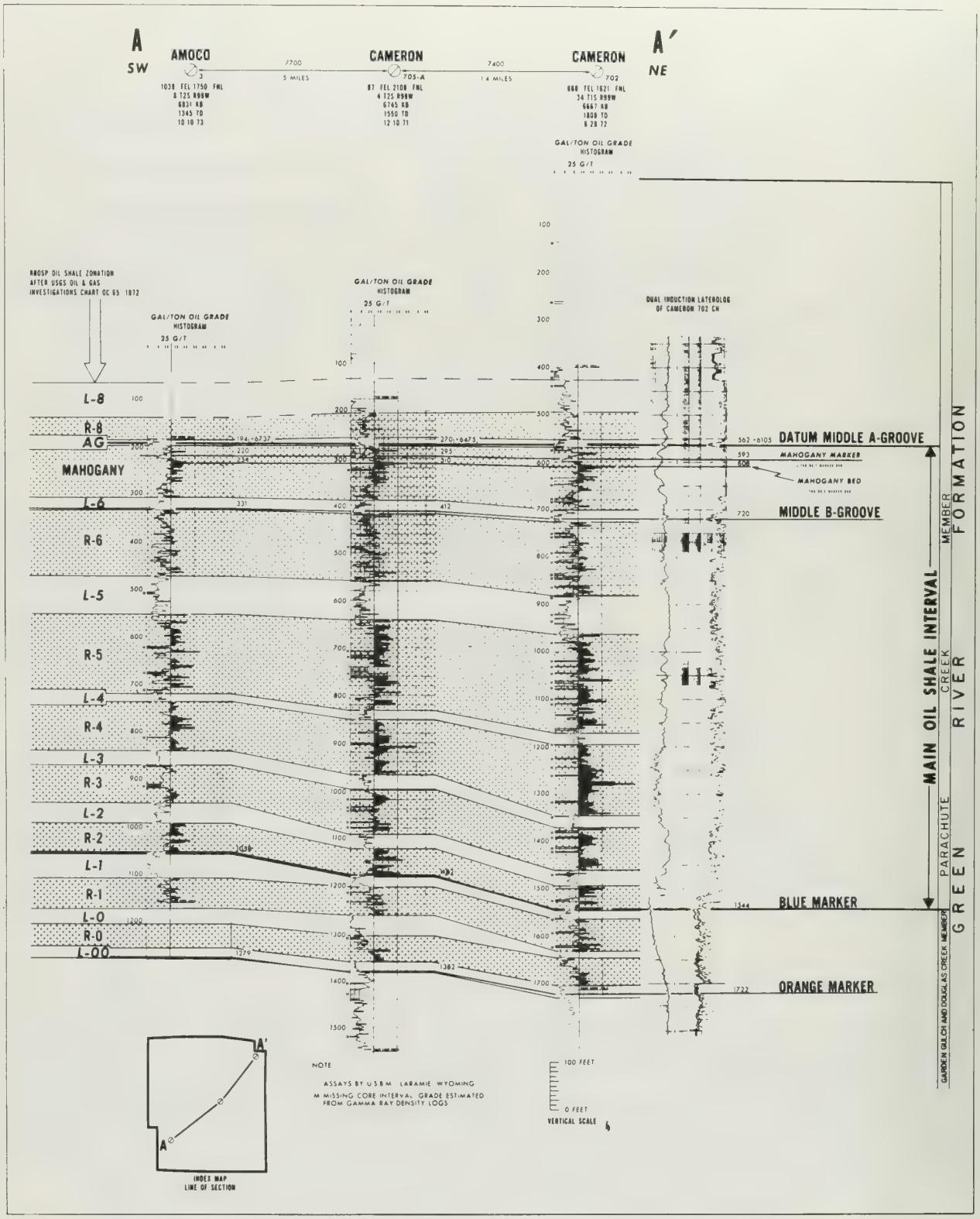

Figure 7-2-5

SW-NE 3-CORE HOLE HISTOGRAM CROSS SECTION, TRACT C-a

concentrations within the tract considerably and resulted in many vugs or solution cavities. As a result, the minor occurrences of nahcolite remaining in the Tract C-a oil shale interval have little commercial value.

Methane and hydrogen sulfide have been detected in the oil shale sections within Tract C-a. The gases are probably trapped in vugs and fractures as well as dissolved in the groundwater.

Quantitative analyses of trace elements were run for antimony, arsenic, boron, cadmium, fluorine, mercury and selenium in fresh shale, processed shale and fresh overburden. Antimony, mercury, and selenium concentrations averaged in the neighborhood of one part per million (ppm); arsenic and cadmium averaged a few parts per million; and boron and fluorine averaged a few hundred ppm.

2. Structure - The Piceance Creek basin is a broad northwest-trending structural trough, the central portion of which is underlain by the Green River Formation in an area approximately 60 miles long and 40 miles wide. Green River Formation sediments around the basin's periphery have been removed by erosion.

Tract C-a is located on the west flank of the Piceance Creek basin about 5 miles east of Cathedral Bluffs. Beds within the tract strike generally to the north and dip basinward to the east and northeast at about 200 to 350 ft/mi (2-4^{o}) except where locally disturbed by folds and faults. The structural framework of Tract C-a is dominated by the Sulfur Creek anticlinal nose and three major en échelon fault systems (graben) on its northeast flank. Four minor folds and multiple subsidiary faults complete the framework.

Figure 7-2-6 is a middle A-groove structure map showing the structural features of Tract C-a. The Sulfur Creek anticlinal nose is a gentle low relief structure which plunges southeastward through the southern portion of the tract. The three northwest-trending en échelon graben essentially

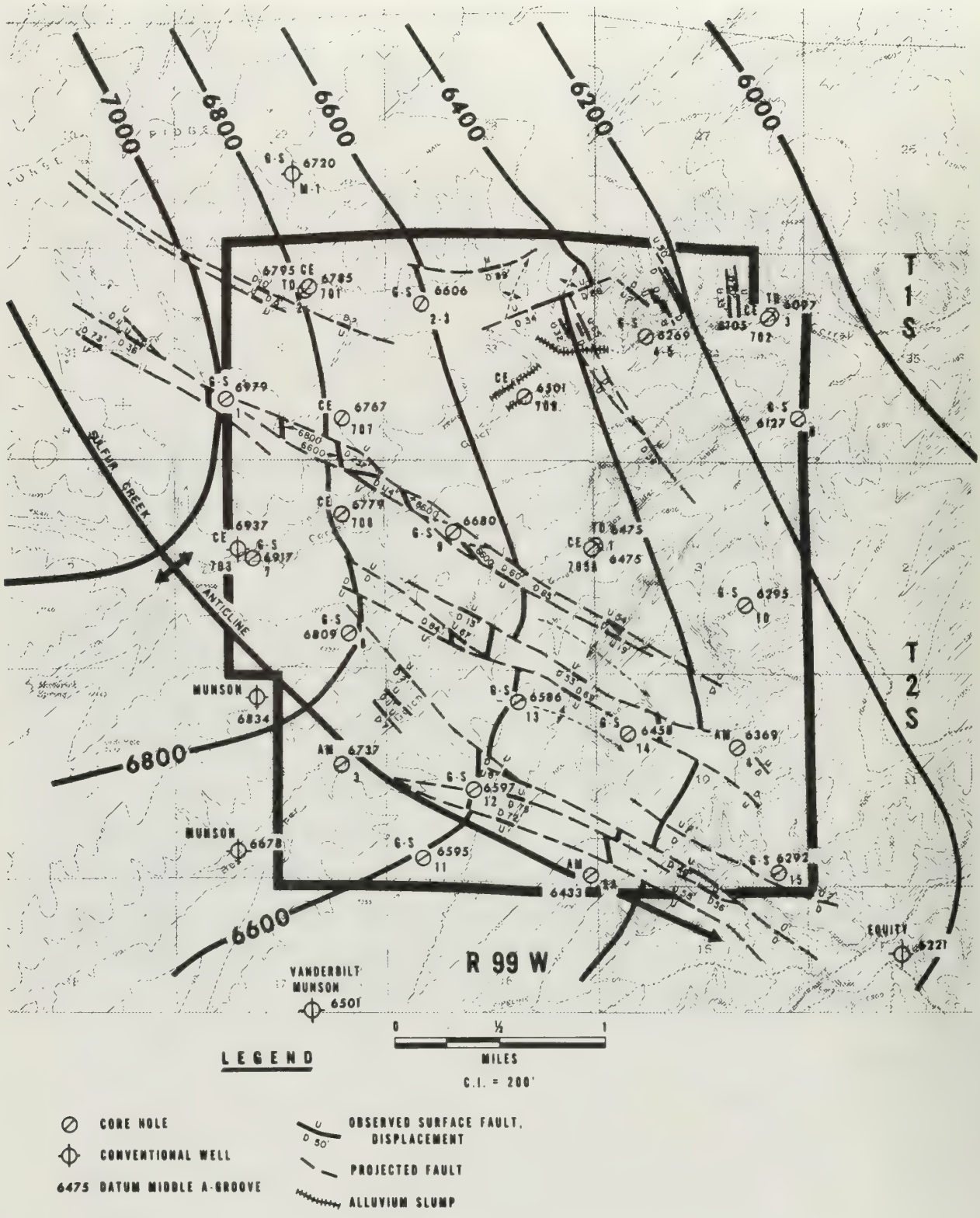

Figure 7-2-6

RBOSP TRACT C-a MIDDLE A-GROOVE STRUCTURE MAP

parallel the Sulfur Creek anticlinical axis. The northernmost graben is the most structurally complex of the three. The combination of cross faulting within this graben together with differential displacement on the graben-bounding faults provide strong evidence that the graben is not one simple downthrown block, but rather a series of broken and tilted (rotated) blocks. Surface fault displacements on Tract C-a range from a few feet to more than 230 feet.

A joint system consisting of three main joint sets is present within Tract C-a with joints in each set generally spaced 10 feet or more apart. The dominant set strikes N56^{o}-76^{o}W with dips of 74^{o}SW passing through vertical to 86^{o}NE. The secondary set strikes N28^{o}E with a dip of 80^{o}NW. The tertiary set strikes N15^{o}W with a dip of 75^{o}E. These joint set orientations are average values for the entire tract. Some variations to these values occur locally.

3. Overburden - Overburden thickness between ground surface and the middle A-groove horizon varies considerably throughout the tract depending upon abrupt local changes in topographic relief. This variable topography together with the general east and northeast gentle dip of the subsurface middle A-groove horizon results in a generally northeast trend to the overburden. Overburden thickness ranges from about 60 to 875 feet with a tract average of about 480 feet. The least overburden is on the far west edge of the tract in Dry Fork and Corral Gulch. The maximum overburden is near the tract's northern border atop the ridge due north of core hole G-S 4-5.

2.2 LAND USE

The principal current activities in the Piceance Creek basin are ranching and stock grazing, big game hunting, and conventional oil and gas field development. Haying is confined to drainage bottoms but stock grazing (primarily cattle) is conducted throughout most of the area.

Although the basin proper is relatively isolated and virtually uninhabited (except for the Piceance Creek valley), accessibility is good. Big game hunting in October and November comprises by far the majority of the recreational use of the area. Tract C-a is located in Colorado Division of Wildlife's (CDOW) big game management Unit 22, one of the most popular deer hunting areas in the state. This Unit 22 has been listed among the top ten (rank range from 1st to 9th) units in the state for the highest number of hunters and largest number of deer harvested for several years (Colorado Division of Game, Fish and Parks 1971, 1972; Colorado Division of Wildlife 1973, 1974, 1975, 1976). The following table presents harvest statistics for Unit 22 and the State of Colorado for the five-year period, 1971-75.

HARVEST STATISTICS[1] FOR UNIT 22 AND THE STATE OF COLORADO FOR THE FIVE-YEAR PERIOD, 1971-75

	Number of Mule Deer Harvested[2]		Hunter Pressure Expressed In Hunters per Square Mile	
Year	Game Management Unit 22	State of Colorado	Game Management Unit 22	State of Colorado
1971	3,046	40,056	5.38	0.91
1972	5,446	66,109	7.27	1.24
1973	2,030	75,451	4.43	1.60
1974	1,982	54,142	[3]	[3]
1975	2,191	39,084	4.21	1.24

[1] Data from Big Game Harvest Statistics published yearly by the Colorado Division of Wildlife 1972, 1973, 1974, 1975 and 1976.

[2] Includes all deer harvested from 1970 and all deer harvested exclusive of archery for 1971-75.

[3] Not listed for 1974.

The harvest has declined in recent years, primarily because of lower mule deer population levels. More non-residents than residents hunt in Unit 22. Limited elk hunting occurs west of Tract C-a as well.

Small game and waterfowl are not as heavily hunted as big game animals. The small game animals harvested in the vicinity of Tract C-a include the cottontail rabbit, mourning dove, sage grouse, and blue grouse. Waterfowl hunters generally hunt Rio Blanco Lake, the White River, and Piceance Creek and its larger tributaries, but seldom hunt near Tract C-a. Most waterfowl harvested are migrants. Predator hunting of coyotes and, to a lesser extent, bobcats, is practiced in the area for sport and fur.

Trapping intensity varies, depending upon the price of furs. Relatively little trapping for a particular species occurs until prices paid for pelts reach a profitable level. Trapping in the tract area is primarily limited to coyotes, bobcats, and occasionally weasels.

Before enactment of the Wild Horse and Burro Act in 1971, some local ranchers occasionally captured feral horses. These animals are now under jurisdiction of The Bureau of Land Management and are fully protected.

Other recreational activities such as snowmobiling, jeeping, hiking, hunting for gemstones, minerals and artifacts, scenic viewing from Cathedral Bluffs, observing wildlife like the feral horses, and short trips focused on appreciating the relatively remote and undisturbed area are not as publicized as hunting; nevertheless, these represent additional important human uses of the area's resources. The level of resource use for these activities is not as easily quantified as is hunting or livestock grazing since people involved in the activity are not required to have a license or to register their activities.

While the Piceance Creek basin may be characterized as a beautiful and relatively unspoiled natural setting, it is not particularly spectacular scenery, nor does it contain any exceptional natural, archaeological, or historical sites. The fact that the Piceance Creek basin is not attractive to tourists and others pursuing outdoor recreational experiences is also attributable to the close proximity of many well known areas such as:

- Dinosaur National Monument
- Black Canyon National Monument
- Flaming Gorge National Recreation Area
- White River National Forest
- The Colorado Rockies
- Colorado National Monument

Residential dwellings are widely separated in this sparsely populated area. Those residences that are present are usually associated with ranching and, to some extent, hunting. A hunting club once owned several permanent buildings on Tract C-a that were used during the big game season.

Because no fishery exists on or near Tract C-a, and because the fishery of the White River is generally limited to rough and forage species below the confluence of Yellow Creek, there is essentially no human utilization of the aquatic biota of the area other than for scientific studies.

In prehistoric times, Ute Indians originally occupied and used the local resources. As white men settled the area and the Indians were forced to relinquish their holdings, the livestock industry became established and continues to be of primary importance in the region. Three Bureau of Land Management (BLM) grazing allotments have been established in the vicinity of Tract C-a. They are composed of Federal, State (Division of Wildlife and state school) and private holdings.

Ranching requirements have led to changes in the fauna of the region. Large predators have been gradually eliminated or drastically reduced in numbers because they affected the profitability of the livestock industry. Animals such as bears, cougars, and wolves were systematically removed by trapping and bounty hunting. The American bison (buffalo), a native ungulate, was extirpated by uncontrolled hunting before the cattle industry began. Reintroduced in the early 1960's, buffalo proved to be incompatible with livestock interests. The herd of approximately 30

animals could not be contained by conventional fences and was consequently removed in 1973-1974.

A limited amount of vegetation manipulation such as sagebrush eradication by burning and aerial herbicide application has been used on public lands within the study area. On private lands along streams to the southeast and northeast of Tract C-a, arable lands have been converted to hay fields.

2.3 SURFACE AND SUBSURFACE HYDROLOGY

The Piceance Creek basin can be defined in terms of the geologic basin, which includes parts of Moffat, Rio Blanco, Garfield, Gunnison and Mesa counties, or the hydrologic basin, which encompasses a much smaller area than the geologic basin. The hydrologic basin covers an area of approximately 900 square miles and is bounded on the north by the White River, on the east by Colorado Highway No. 13, on the south by the Roan Plateau, and on the west by Cathedral Bluffs (Figure 7-2-7).

Baseline studies on the hydrology of Tract C-a and vicinity were conducted over a 2-year period to determine quantity, quality, and source of surface waters in the area and to identify subsurface water sources and their characteristics. These studies are critical to the assessment of development impacts on local and regional water supplies.

Baseline conditions were identified through studies of precipitation, springs and seeps, surface water, alluvial aquifers, and deep bedrock aquifers. Complete descriptions of these conditions are found in RBOSP quarterly progress reports and a complete analysis of the 2-year data appears in the RBOSP Final Environmental Baseline Report (1977).

The precipitation data from the gaging stations indicate a range of 10.7 to 17.2 inches of precipitation per year as shown on Table 7-2-1. Values are adjusted to account for storage type gage evaporative losses,

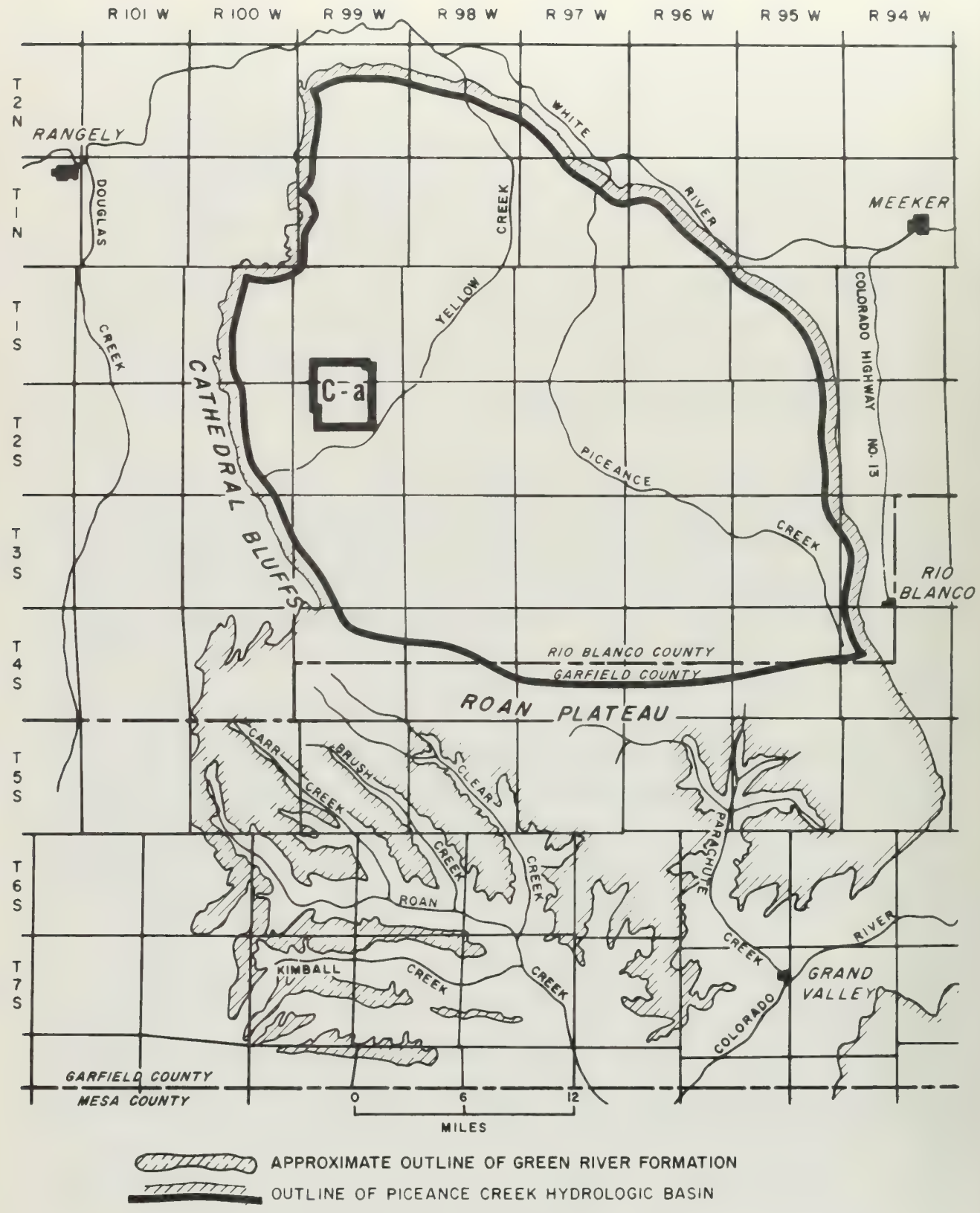

Figure 7-2- 7

PICEANCE CREEK BASIN HYDROLOGIC BASIN

and irregular data collection during heavy precipitation events. They therefore represent most probable values over the baseline period.

Table 7-2-1

PRECIPITATION SUMMARY

Water Years 1975 and 1976

	1975			1976		
	Monthly Maximum	Monthly Minimum	Total	Monthly Maximum	Monthly Minimum	Total
Cathedral Bluffs	2.87	.43	16.30	2.49	.40	17.25
Tract C-a*	2.43	.16	13.25	1.97	.12	11.83
Yellow Creek	1.67	.04	10.85	1.91	.29	10.72

*1975 from Stakes Springs Draw Data;
1976 from average of Dry Fork, Corral Gulch, Box Elder Gulch and Stakes Springs Draw stations

Two basic weather systems affect precipitation in the study area. Frontal systems generally result in widespread, uniform precipitation. Convection systems or thunderstorms result in erratic patterns of precipitation over an area of a few square miles.

The drainage system for the study area, including locations of gaging stations and rain gages which were the source of data for baseline studies are shown in Figure 7-2-8. Peak stream flows usually occur after spring snowmelt (March - April) and lows occur in late summer or early fall (August to November). Annual runoff (October 1 to September 30 of each year) at seven stations in the study area is shown in Table 7-2-2.

Both Corral Gulch (east) and Yellow Creek sustained baseflow for the period of record, with Yellow Creek having higher discharges. Box Elder and Corral Gulch (west) do not sustain a baseflow. However, both showed effects of snowmelt. Thirty-seven springs and seeps (Figure 7-2-9) were identified in the study area. These appear to be fed by alluvial or shallow bedrock aquifers or a combination of both. Six of these were studied in detail, including water quality and velocity.

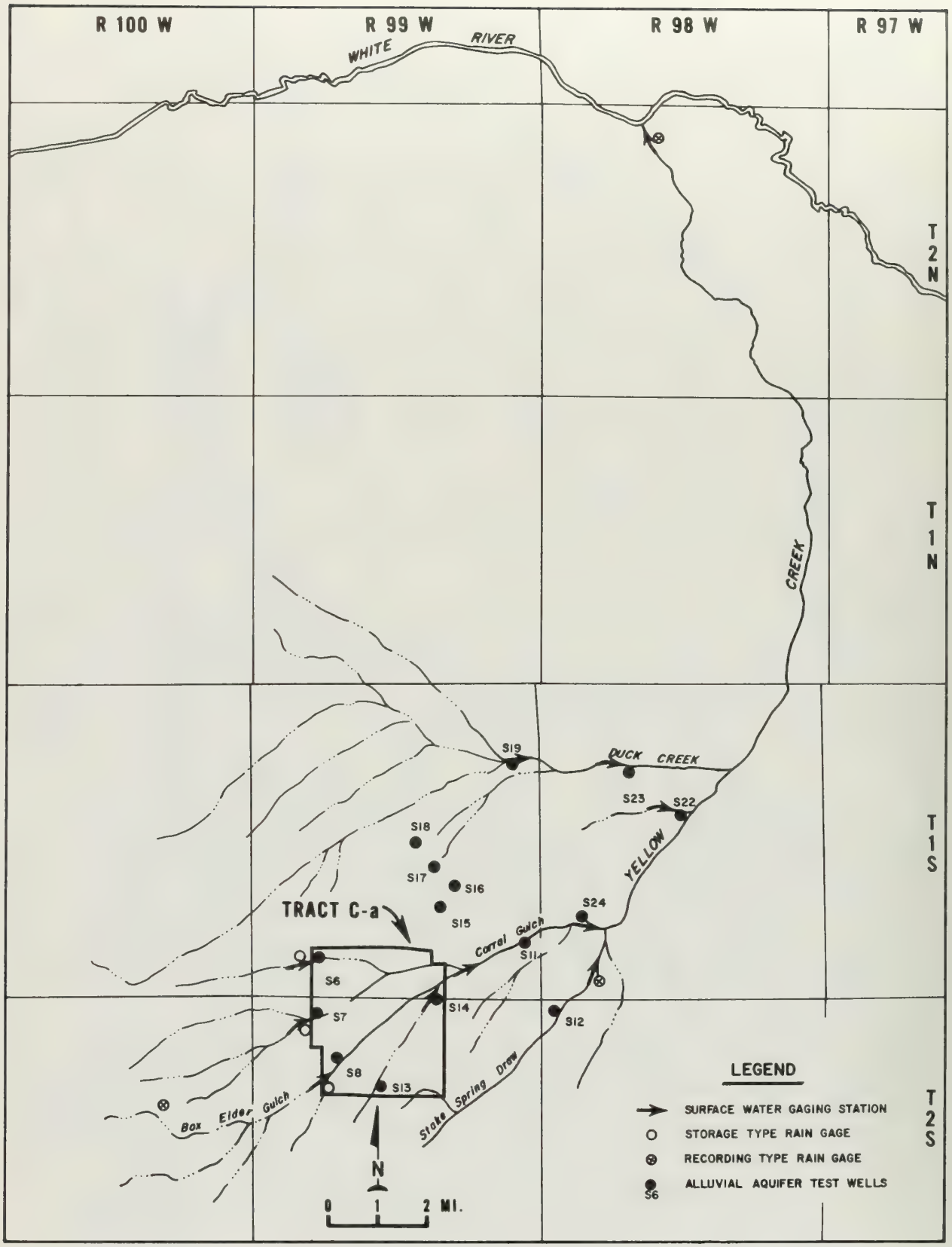

Figure 7-2-8
YELLOW CREEK DRAINAGE BASIN

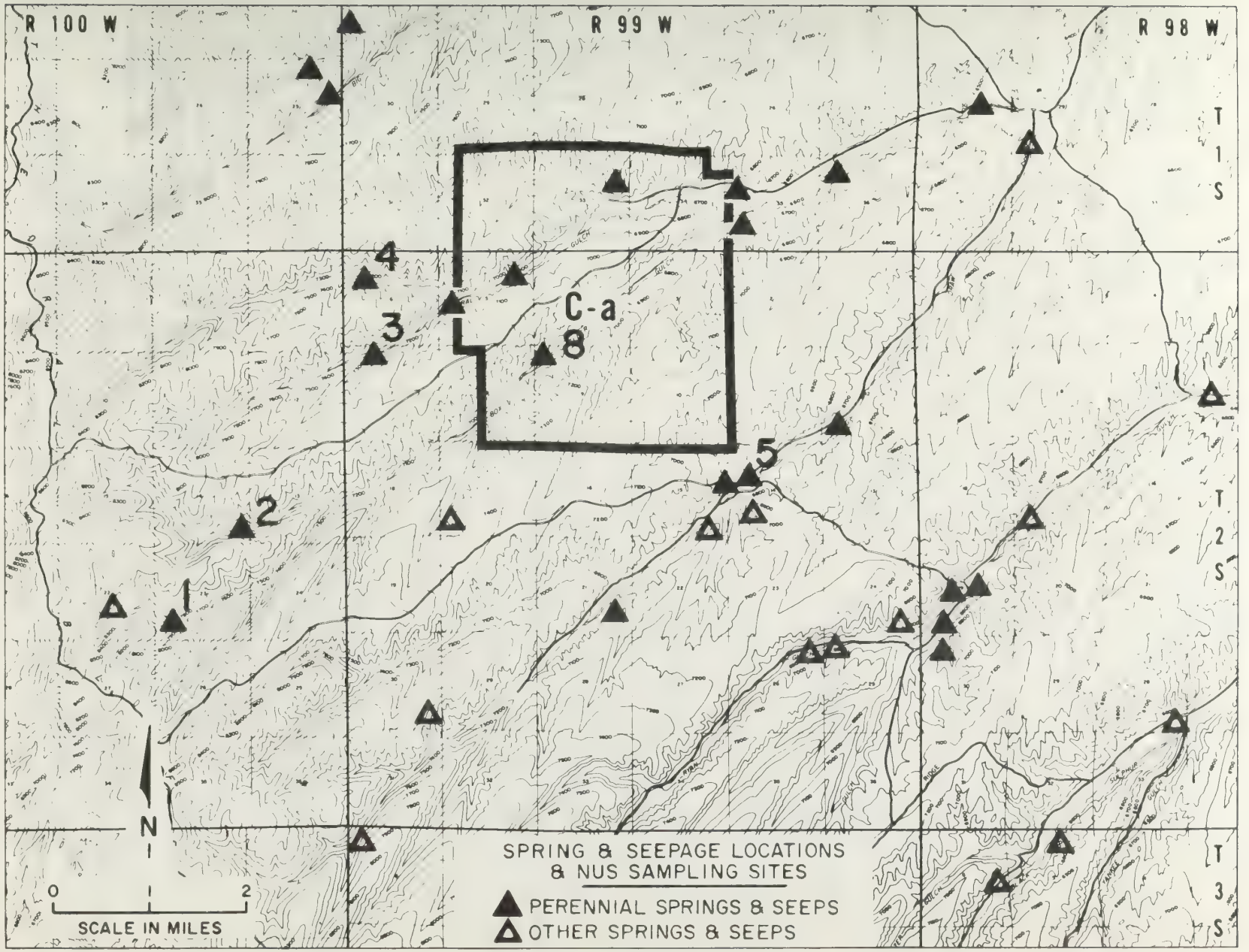

Figure 7-2-9

LOCATIONS OF SPRINGS AND SEEPS IN THE STUDY AREA

Table 7-2-2

ANNUAL RUNOFF IN ACRE-FEET

STATION	WATER YEAR 1974[1]	WATER YEAR 1975	WATER YEAR 1976
Dry Fork near west line Tract C-a	1.4	0.2	4.3
Corral Gulch near west line Tract C-a	134.0	96.7	98.5
Box Elder Gulch near west line Tract C-a	148.4	182.8	34.8
Rinky Dink Gulch near east line Tract C-a	no data	0.6	2.3
Corral Gulch near east line Tract C-a	309.3	626.2	418.1
Stakes Spring Draw near Confluence with Corral Gulch	0.0	0.0	15.5
Yellow Creek near White River	1740[2]	1158.7	1103.1

[1] March through September only
[2] Complete Records for Water Year 1974

Drainages within the Piceance Creek basin have not been classified by the Colorado Water Quality Control Commission, but the White River has. The White River and tributaries from its source near Trapper's Lake to the mouth of Piceance Creek is quality class B. The main stem of White River from the mouth of Piceance Creek to the Colorado-Utah state line is quality class B_2. Waters designated class B_1 or B_2 are waters suitable or that may become suitable for all purposes for which raw water is customarily used, except primary contact recreation such as swimming and water skiing.

Water quality of streams in the study area, as indicated by continuous specific conductance, generally worsens downstream. Seasonal variations show the highest average values during the winter before snowmelt begins. Temperature follows seasonal trends while suspended sediment load is generally related to flow (above certain flow threshold rates) and rate of change of flow.

Along the stream reaches on Tract C-a, iron, pH, and total dissolved solids (TDS) exceed suggested drinking water limits. Along the lower reach of Corral Gulch on Tract C-a and in Yellow Creek, groundwater inflows cause increased hardness, fluoride, and sodium. White River water quality responds to the influx of Yellow Creek water as would be expected through proportioned mixing.

Three distinct groundwater systems occur in the area: surface alluvial aquifer, the upper bedrock artesian aquifer, and the lower bedrock artesian aquifer. The alluvial aquifer occurs along major stream valleys and are quite variable in thickness. On Tract C-a, alluvium is present along Corral Gulch, Dry Fork, Rinky Dink Gulch, and Box Elder Gulch. The alluvial aquifer is hydraulically connected with the streams of the region and thus show seasonal variation. In general, the concentrations of sodium and dissolved solids in the upper aquifer increase down gradient and reach highest values near the northeast corner of the tract. Calcium concentrations are more variable.

Of the major chemical water constituents in the lower aquifer, Ca, Mg, and SO_4 decreased on the average, over the 2-year baseline period. Na, Cl, HCO_3, K, and SiO_2, and TDS showed a slight average increase.

2.4 CLIMATE AND AIR QUALITY

Climatology and air quality baseline studies were initiated for Tract C-a in February 1975 and were completed in January 1977. A complete complement of climate and air quality measurements was taken within 3 km of the anticipated point of highest effluent concentrations from plant facilities. In addition to this site, three other sites (Figure 7-2-10) were set up to monitor various climatology and air quality parameters. Complete descriptions of the RBOSP air monitoring network appear in previously published quarterly progress reports (RBOSP, 1975, 1976, 1977). Monitoring parameters included wind speed and direction, ambient air temperature, delta temperature, relative humidity, precipitation, carbon

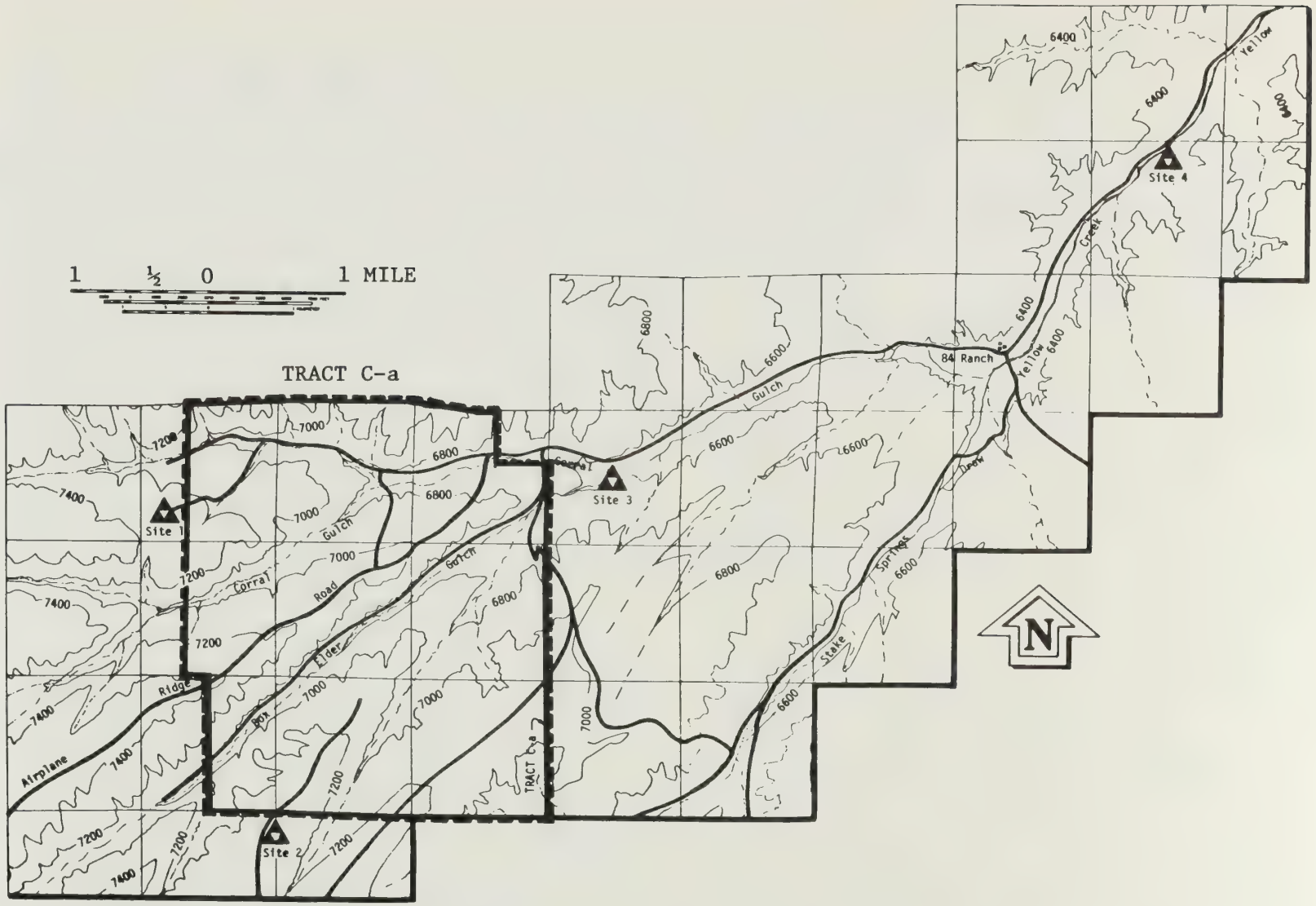

Figure 7-2-10

TOPOGRAPHIC MAP OF AREA AROUND TRACT C-a SHOWING LOCATIONS OF METEOROLOGICAL AND AIR QUALITY STATIONS

monoxide, oxides of nitrogen, nitric oxide, ozone, hydrocarbons particulates, solar radiation, evaporation rate, noise, and visibility. The results of these studies are presented in the RBOSP Final Environmental Baseline Report (1977).

There are two primary air quality regions whose regulatory criteria apply to Tract C-a. These areas are called Yampa Intrastate Air Quality Control Region (AQMA), (Figure 7-2-11).

The general climate recorded on Tract C-a during the 2 years of baseline studies agree well with regional long-term conditions recorded at Grand Junction, Colorado. The long range climate of the area surrounding the tract is similar to semi-arid steppe regions. The annual precipitation is 10 to 12 inches, but is strongly dependent on local topography and elevation.

Since the entire Piceance Creek basin is surrounded by high mountains, or ridges, many migratory low pressure systems are deflected around the region. Stationary high pressure cells often last for several days, because their passage is blocked by high mountains to the east. As a result, there is a high frequency of clear, sunny days, with high winds and large diurnal temperature changes. Ambient temperatures are moderate during the spring, summer, and fall; winter minimum temperatures are low. Gradient winds are generally the prevailing westerlies which occur year round, but are interrupted occasionally by the passage of frontal systems.

Specific air movements are affected by local topography. Wind velocities tend to be lowest at dawn, when there is little vertical thermal mixing and the lower surface air does not mix with the more freely moving upper air. During warm afternoons, the laterally constricted, but vertically expanded air tends to blow up the valley. At night the process is reversed as the colder, more dense air at higher elevations drains into the depressions.

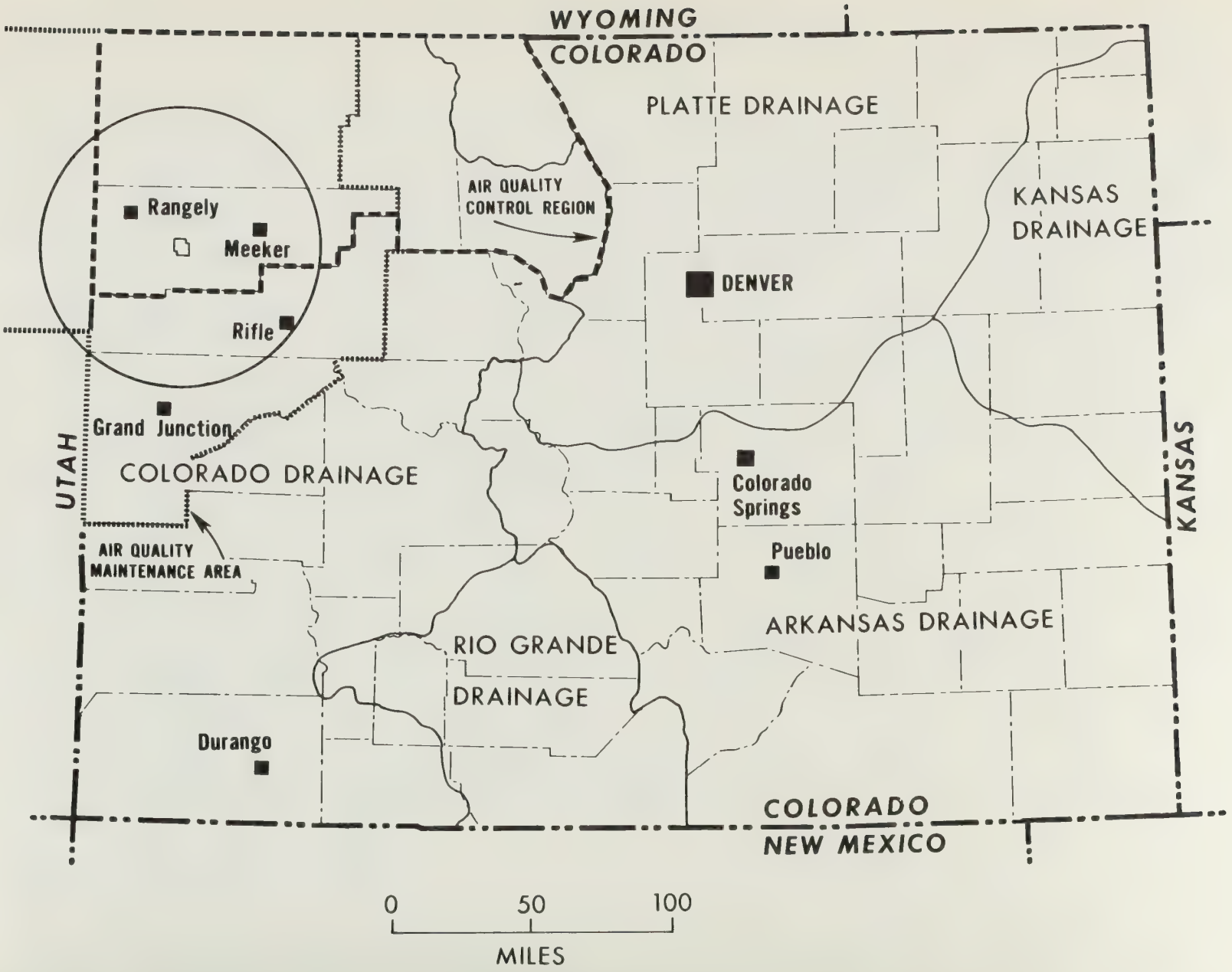

FIGURE 7-2-11

THE STATE OF COLORADO, SHOWING THE YAMPA INTRASTATE AQCR, THE OIL SHALE AQMA (COLORADO PORTION), AND A 50-MILE-RADIUS CIRCLE CENTERED ON THE RBOSP TRACT C-a. THE FIVE MAJOR RIVER DRAINAGE BASINS ARE ALSO SHOWN.

Annual precipitation summaries indicate that for the Tract C-a area the baseline year 1975-1976 was considerably drier than 1976-1977. The monthly averages in 1975-1976 ranged from 0.03 to 0.51 inches. Second year averages ranged from 0.02 to 1.38 inches during October, November, and December.

Air quality measurements indicated that most gaseous constituents are low, often near the lower detectable limits of the instruments. Ozone, hydrocarbons and particulates occasionally exceeded Federal and State ambient air quality standards. During the first year of baseline studies nonmethane hydrocarbons exceeded standards 94 times, ozone exceeded standards 5 times, and particulates exceeded standards 10 times. Standards were exceeded less often during the second year -- non-methane hydrocarbons - 43 times, ozone - 0, and particulates - 10.

In general, visibility over Tract C-a is exceptionally good. Minimum visibility exceeded 100 miles 50% of the time during the first year and 80 miles 50% of the time during the second year. Decreased visibility during the second year was related to cloud formations and haze conditions.

Noise studies in the area represent fairly low pristine levels. Noise measurements taken during the first noise survey are somewhat higher than measurements taken during the second survey. These differences are attributed to variations in wind speeds during the two periods.

2.5 TERRESTRIAL ECOLOGY

Comprehensive, 2-year terrestrial studies were initiated in October, 1974 to assess and document pre-development wildlife inventories and baseline environmental conditions of the Tract C-a area. Results of this 2-year study and extensive analyses of data collected during the study appear in the RBOSP Final Environmental Baseline Report for Tract C-a and Vicinity (1977). A complete description of methods used and results of the first year's study was published in the RBOSP Annual

Terrestrial Baseline Report (1976) and in previous RBOSP quarterly progress reports. All these reports are on file at the Area Oil Shale Supervisor's Office (AOSO). A summary of the terrestrial ecology of Tract C-a and vicinity follows.

A. Vegetation - A total of 8 vegetation types and 7 associations (Table 7-2-3) has been identified in the study area. The majority of the study area (Tract C-a and a 5-mile perimeter on all sides) is occupied by pinyon-juniper and sagebrush vegetation types (68% of total area). Elevational ranges of these two types overlap, with sagebrush occupying the valleys, mesas or gentle slopes with fine, deep soils and pinyon-juniper occupying ridges and steep or rough slopes having coarse, rocky or shallow soils (Table 7-2-3). Competitive interactions between the two types are more apparent where soil types and slopes intergrade. The mixed brush vegetation type prevails on north-facing slopes where winter snow accumulates.

The most extensive vegetation type in the Piceance Basin and the study area is dominated by pinyon-pine and Utah juniper, together ranging in height from 3-7 m (10-22 feet). The pinyon-juniper type occupies approximately 41% of the mapped portion of the study area. This type, as a whole, represents one of the most important vegetation types in the Tract C-a ecosystem because it provides a critical food supply and source of shelter for animals inhabiting the area during the winter, as well as providing nesting sites and cover for species inhabiting the type during the summer. Percent cover in this type during the study period ranged from 4 to 9% in the shrub stratum and from 17 to 25% in the tree stratum (RBOSP Progress Report 10, 1977).

Annual production is estimated to be greatest in the pinyon-juniper-mixed brush association, followed by the pinyon-juniper-sagebrush and the pinyon-juniper-woodland associations, based on the extent of the development of the shrub stratum, and relative cover and density of the tree stratum. Estimates of production from the herbaceous stratum from sites scattered over the type equaled a mean of 101 lbs/A (114 kg/ha) during 1975.

Table 7-2-3

GENERAL INFORMATION REGARDING VEGETATION TYPES AND ASSOCIATIONS SAMPLED IN THE TRACT C-a VICINTIY DURING 1974-1976 FOR RBOSP

Vegetation Type	Elevation	Exposure	Extent in Study Area	Soil Condition	Dominant Species
Aspen	2435 m (8,000 ft)	north- and east facing	961 acres (<1%)	deep, sandy loams with large accumulations of organic matter	serviceberry sp elk sedge
Douglas-Fir	2380 m (7,800 ft)	north- and east facing	1,598 acres (1%)	shallow soils	Douglas-fir serviceberry snowberry elk sedge
Mixed brush	2100-2250 m (7,000-8,500 ft)	all slope aspects	27,388 acres (25%)	deep, sandy loams and shallow soils above shale outcroppings	Utah serviceberry big sagebrush elk sedge
Pinyon-juniper woodland	1950-2250 m (6,500-7,500 ft)	all slope aspects	621 acres (<1%)	Rentsac soil series	pinyon juniper sandberg bluegrass slender wheatgrass
Pinyon-juniper mixed brush	2100-2250 m (7,000-7,500 ft)	north- and south facing	24,258 acres (22%)	Rentsac soil series	pinyon juniper Utah serviceberry big sagebrush sandberg bluegrass
Pinyon-juniper sagebrush	1950-2250 m (6,500-7,500 ft)	all slope aspects	20,288 acres (18%)	Rentsac soil series	juniper pinyon big sagebrush sandbergh bluegrass slender wheatgrass
Sagebush upland	1950-2550 m (6,500-8,500 ft)	all slope aspects	21,527 acres (20%)	Rentsac, Piceance, and Yamac soils series	big sagebrush Douglas rabbitbrush sandberg bluegrass Hood phlox
Sagebrush bottomland	1950-2550 m (6,500-8,500 ft)	all slope aspects	7,262 acres (7%)	Glendive soil series	big sagebrush Douglas rabbitbrush western wheatgrass Great Basin wildrye
Sagebrush greasewood	1950-2550 m (6,500-8,500 ft)	slope aspects characteristic of study area drainages	1,087 acres (1%)	alluvial soils	greasewood big sagebrush rubber rabbitbrush cheatgrass goosefoot
Sagebrush rabbitbrush	1950-2550 m (6,500-8,500 ft)	slope aspects characteristic of study area drainages	679 acres (<1%)	alluvial soils	rabbitbrush Great Basin wildrye goosefoot cheatgrass
Bald	2170-2565 m (7,230-8,550 ft)	west facing	2,087 acres (2%)	Rentsac soil series	Utah serviceberry green rabbitbrush sandberg bluegrass slender wheatgrass prairie junegrass
Shadscale	1938-2045 m (6,460-6,810)	steep south facing slope adjacent to major drainages	1,280 acres (1%)	rock outcrops or very shallow soils	shadscale big sagebrush criogonum fringed sagewort
Riparian	1950-2250 m (6,500-7,500 ft)	all slope aspects	185 acres (<1%)	wet	big sagebrush water birch quackgrass Kentucky bluegrass

The sagebrush type on the study area is characterized by the constant presence, moderate (2 to 31%), cover and high density (2981 to 9633/ha) of big sagebrush in the shrub stratum and by an herbaceous stratum with high species diversity (up to 54 species), and cover from 15 to 50%. Mature sized trees are generally absent from this type (RBOSP Final Environment Baseline Report, 1977).

The sagebrush type occupies approximately 29% of the study area. The areal extent of the associations which comprise the sagebrush type is divided as follows: bottomland sagebrush, 7%; upland sagebrush, 20%; rabbitbrush, 1%; and greasewood, 1%. The percent cover in the shrub stratum totals 46, 39, 40 and 44%, respectively.

The mixed brush type is characterized by the tall, 1-3 m (3-10 feet), life form of three species, Gambel oak, Utah serviceberry, and true mountain mahogany (Cercocarpus montanus). Shorter shrubs, 1 m (3 feet), consisting of big sagebrush and snowberry coexist with the taller species. These species, with the exception of mountain mahogany and big sagebrush, form large patches due to clonal growth. The mixed brush type occupies approximately 25% of the mapped portion of the study area. The shrub stratum has a combined cover of 57%, ranging from .1 (gray horsebrush and pinyon-pine) to 27% (Utah serviceberry).

Production of these vegetation types for Tract C-a and vicinity ranged from 268 lbs/A for sagebrush to 100 lbs/A for pinyon-juniper (Table 7-2-4).

At the lower elevations of the study area, black greasewood becomes more abundant within the sagebrush type on saline alluvial soils. Shadscale occurs within this type as well as on alkaline south-facing slopes along major drainageways. Both occupy less than 1% of the total study area (Table 7-2-3).

Table 7-2-4

AVERAGE FORAGE PRODUCTION ESTIMATES[1]
FOR THREE VEGETATION TYPES ON AND NEAR TRACT C-a DURING FALL 1975

Tract C-a Vegetation Type	Dry Weight Production lbs/A (kg/ha)
Pinyon-Juniper	100.5 (113.6)
Sagebrush	268.7 (303.6)
Mixed Brush	206.6 (233.5)

[1]Table values have been adjusted to correct for minor errors in results reported in RBOSP Annual Terrestrial Baseline Report, (1976).

The higher elevations of the study area support the mixed brush type, characterized by the tall-shrub life form of Utah serviceberry, Gambel oak and mountain mahogany. This type occupies moist slopes, which are too cool for pinyon-juniper and too dry for aspen. Aspen and Douglas fir types (<1 and 1% of the study area) occur on the steep, generally north-facing slopes near Cathedral Bluffs, with aspen usually occupying a position of slightly lower elevation than Douglas-fir. Ridgetops approaching Cathedral Bluffs support sagebrush which intergrades with upland meadows that are characterized by low, drought-resistant grass and forb species in dry, wind-exposed areas.

Riparian vegetation types are uncommon (<1%) on Tract C-a and are restricted to small springs in open, alluvial bottomlands. Most of these areas, i.e., Stakes Springs, have been converted to pasturelands. Other, more typical riparian vegetation species, (e.g. water birch, willow, and red osier dogwood) are found adjacent to springs and seeps along steep draws. An example of this vegetation type is Cottonwood Spring. It is not heavily grazed and contains a number of plant species which are unusual in the Piceance Creek basin (e.g. columbine, fowl mannagrass). A third type of riparian vegetation is found along drainageways of intermittent streams. This type generally contains species characteristic of the bottomland sagebrush association (e.g. big sagebrush, Douglas rabbitbrush, mountain snowberry, Sandberg bluegrass, Hood phlox, and elk sedge).

Browse in the study area was determined to be almost entirely within the "Good" condition class (98.4%). A much smaller area (1.4% of the study area), was placed in the "Fair" condition class. Only 0.2% of the study area, all in the Douglas-fir type, was judged to be in "Poor" browse condition as a result of baseline analysis.

Within mixed brush associations, browse utilization was highest for mountain mahogany and bitterbrush (47%). In pinyon-juniper associations, bitterbrush was most heavily utilized (74%), followed by serviceberry (69%) and mountain mahogany (53%). For nearly all browse species, the percentage of utilization was higher in the pinyon-juniper type than in the mixed brush type. This was particularly true for bitterbrush (74% in pinyon-juniper versus 47% in mixed brush) and serviceberry (69% in pinyon-juniper versus 11% in mountain brush) (RBOSP Final Environmental Baseline Report, 1977).

B. Small Mammals - Thirty species of small and medium-sized mammals occur in the vicinity of Tract C-a. Trapping results have been used to establish the distribution and abundance of small mammal populations on Tract C-a. Generally, vegetation types with the greatest amount of shrub cover (greasewood/sagebrush, rabbitbrush, and mixed brush) exhibited the greatest apparent abundances of small mammals. The least chipmunk and deer mouse were the two most abundant species trapped in these and many other vegetation types. They comprised over 80% of all small mammals captured in the study area.

At higher elevations (above 8,000 feet) fewer species of small mammals were captured and relative abundances were apparently lower. Two species, the red-backed vole and the red squirrel, are reportedly limited to aspen and Douglas-fir stands similar to those found on Cathedral Bluffs.

More species of small mammals were captured in pinyon-juniper than in any other vegetation type; probably because of the greater habitat heterogeneity. Two species, the piñon mouse and Colorado chipmunk, were found only in this type, and the bushy-tailed woodrat and golden-mantled ground squirrel exhibited an affinity for pinyon-juniper habitat.

Other small mammal species comprising only a small proportion of the total number captured include the thirteen-lined ground squirrel, long-tailed vole, montane vole, and sagebrush vole. The northern pocket gopher and porcupine are also residents of the Tract C-a area as are three lagomorph species, Nuttall's cottontail, the black-tailed jackrabbit, and the white-tailed jackrabbit.

Three insectivores, the masked shrew, wandering shrew and Merriam's shrew (a first record for the Piceance Creek basin) have been identified to date (R. Finley, United States Fish and Wildlife Service (USFWS), 1975, personal communication). Seven bat species, the hoary bat, big brown bat, silverhaired bat, and four species of myotis have also been found in the study area.

The concepts of species diversity and total abundance were combined in an objective rating system to determine the relative importance of sampled habitats to small mammal populations. Habitats at lower elevations characterized by high shrub and/or tree cover -- e.g., bottomland sagebrush, pinyon-juniper/mixed brush, pinyon-juniper (south slope), pinyon-juniper (north slope), pinyon-juniper/sagebrush, and rabbitbrush -- supported greater diversities and abundances of small mammals than the other habitats investigated.

Relative abundance was determined to be the most important determination of species importance in the study area. Accordingly, the deer mouse and least chipmunk, accounting for 43.4 and 41% of the total trappable small mammal fauna, respectively, were determined to be the most important small mammal species in the vicinity of Tract C-a. These species were found in samples from every habitat and were the most abundant species in every habitat except Douglas fir and aspen (the red-backed vole is a predominant species in these habitat types). Since the least chipmunk and the deer mouse are both primarily seed-eaters, as are most of the small mammal species encountered in the study area, and both occupy the same ranges in the study area, the potential for inter-species competition is great. Competition appears to be avoided, however, by different

activity periods -- the deer mouse is nocturnal while the least chipmunk is diurnal -- and by differential utilization of habitats: the deer mouse showed a greater affinity for habitats characterized by a high shrub cover and few trees, while the least chipmunk was more closely associated with pinyon-juniper. The relative affinities of each small mammal species for each habitat, as defined by chi-square values, are presented in the RBOSP Final Environmental Baseline Report (1977). A total chi-square value for a species over all habitats greater than 22.36 indicated a deviation from a random distribution among habitats at the 95% confidence level.

C. Big Game - Big game species in the study area include mule deer and elk. Mule deer are the more important of the two in terms of numbers, and recreational value. Relatively few elk (15 to 20) are located in the study area and none were observed within the boundaries of Tract C-a during the baseline studies.

Mule deer use Tract C-a mainly as transitional and upper winter range. They begin moving into the area in October during their migration from higher elevations west and south of Tract C-a to winter range north and east of the tract. This movement is a gradual drift of the animals, probably in response to temperature declines and increased snow depth in their higher-elevation summer range and so movements may vary from year to year. Mule deer may use Tract C-a throughout the winter but as snow levels increase, the largest concentrations of deer are located in the pinyon-juniper and sagebrush vegetation types northeast of the tract. During late April and early May, the largest herds of mule deer characteristically occur in the meadows and bottomlands east of the tract. Movement back to the summer range takes place over an extended period. The deer gradually drift to the higher elevations as individuals and small groups. By late May, most of the deer in the study area are on their summer range (higher elevations west of Tract C-a). Numbers of deer seen during aerial surveys of in the study are shown in Tables 7-2-5 and 7-2-6.

Table 7-2-5

MULE DEER OBSERVED ON FOUR CENSUS AREAS DURING 11 SURVEY PERIODS, WINTER, 1974-1975 for RBOSP

Date of Census	Tract C-a	East	West	North of[1] Tract	Total Observed
November 8, 1974	14	7	12	--	33
November 21, 1974	0	1	2	--	3
December 9, 1974	12	103	64	--	179
December 30, 1974	60	105	130	--	295
January 14, 1975	33	62	16	--	111
February 1, 1975	24	95	2	4	125
February 12, 1975	30	75	0	14	119
March 4, 1975	7	229	0	8	244
March 13, 1975	14	296	0	14	324
April 3, 1975	24	220	4	10	258
April 14, 1975	12	469	0	19	500

[1]Censuses of this area commenced during February, 1975.

Table 7-2-6

MULE DEER OBSERVED DURING 16 SURVEY FLIGHTS JUNE 1975 TO SEPTEMBER 1976 FOR RBOSP

Date of Census	Transects East of Tract C-a	Transects for Tract C-a and Land to the North and South	Transects West of Tract C-a	Total
June 26, 1975	0	0	0	0
August 18, 1975	0	0	0	0
November 6, 1975	22	4	6	32
November 24, 1975	54	8	71	133
December 4, 1975	40	6	42	88
December 18, 1975	214	11	142	367
January 5, 1976	117	9	44	170
January 29, 1976	143	41	0	184
February 23, 1976	284	2	0	286
March 8, 1976	215	0	0	215
March 17, 1976	172	12	0	184
March 29, 1976	554	55	0	609
April 8, 1976	753	28	5	786
April 25, 1976	368	36	48	452
June 10, 1976	0	0	2	2
August 9, 1976	0	1	2	3

Most mule deer remaining on the study area during the summer were scattered throughout the areas of higher elevation west of Tract C-a. Mule deer numbers were low, and their distribution was scattered. The mixture of aspen, Douglas-fir, sagebrush, and mixed brush vegetation types, combined with the range of slope steepness, and aspects occurring west of Tract C-a, affords a variety of micro-habitats for mule deer. Eighty-five to 92% of the pellet groups accumulated during both summers were located in the mixed brush vegetation type west of Tract C-a.

Tract C-a lies within Game Management Unit 22. This unit is classified by the CDOW as among the top 10 in the state for deer harvest. The contribution of Tract C-a to this harvest cannot be estimated from these data, however, since hunting is not evenly distributed in the area. The hunting club located on tract is an indication that hunting is important in the area.

D. Predatory Mammals - The coyote, the long-tailed weasel, and the shorttailed weasel were apparently the most common mammalian predators in the area. Coyote populations seem to be about average for the region based on a comparison of Tract C-a data with USFWS within areas of similar habitat and physiographic characteristics (United States Department of Interior (USDI), 1973, 1974). Other mammalian predators documented in the study area included: the bobcat, badger, and skunk. Although the mountain lion, black bear, and ringtail have not been observed in the study area, they do occur in the region and may occasionally venture into the region and occasionally into Tract C-a (Baker and McKean, 1971).

E. Avifauna - During baseline studies, 139 avian species were observed in the study area. The following species are common year-round residents: common flicker, horned lark, Steller's jay, scrub jay, pinyon jay, blackbilled magpie, common raven, Clark's nut-cracker, black-capped chickadee, mountain chickadee, plain titmouse, red-breasted nuthatch, and gray-headed junco. Riparian habitats support the greatest bird

density and diversity on an annual basis (RBOSP Final Environmental Report, 1977), while sagebrush and rabbitbrush support the lowest numbers of species and individuals.

Avian abundance, diversity, and local distribution vary seasonally. During summer, the largest number of birds and the greatest species diversity were encountered in riparian, agricultural, Douglas-fir, aspen, and pinyon-juniper vegetation types. During June, the most common summer residents migrating into the area were the mountain bluebird, green-tailed towhee, chipping sparrow, Brewer's sparrow, and vesper sparrow. A sparseness of birds (low diversity and abundance) was exhibited in midwinter. In spring and fall a composite of winter and summer birds occurs.

Many areas may show an uneven pattern of distribution typical of winter, while other areas may host many birds of several varieties (RBOSP Final Environmental Report, 1977).

Two species of upland game birds occur locally. A low to moderate population of sage grouse exists in upland sagebrush and mixed brush vegetation types in the southwestern portions of the study area. Sage grouse also occur on 84 Mesa. Blue grouse are year-round residents along Cathedral Bluffs. A low to moderate population of blue grouse inhabits mixed brush and aspen/mixed brush ecotonal areas during the breeding seasons and dense stands of Douglas-fir and aspen in late fall and winter. The mourning dove is the most widely distributed and abundant (0.3 birds/ha) gamebird in the study area during the spring and fall. It resides in a variety of habitats, but it most often frequents pinyon-juniper and greasewood/sagebrush vegetation types.

In the Tract C-a vicinity, a few surface ponds and intermittent streams create isolated islands of habitat for waterfowl and shore birds. Fourteen species, primarily spring and fall migrants, have been recorded using the area. Of these, the mallard, green-winged teal, blue-winged teal and killdeer, were the most common species.

Two migrant shorebird species, the greater sandhill crane and whooping crane, both of which are unusual to the study area, were observed during baseline studies. Sandhill cranes were observed during the 1975 spring and fall investigations. Sightings of these species were limited to 84 Mesa, at the Stakes Springs Draw impoundment and in the agricultural habitat along Yellow Creek. In April and May 1976 two more small groups (2 and 4) of sandhill cranes were sighted in the area. The whooping crane sightings occurred during May at the same time the group of 4 sandhill cranes was seen. The population of greater sandhill cranes that nests in Colorado has been recognized as "endangered" by the CDOW. This designation does not apply to birds that stop in Colorado only during migration periods. The whooping crane is on the 1975 federal endangered species list.

It is doubtful that the Colorado breeding population of Sandhill cranes uses the RBOSP study area. However, the sighting of the mixed flock of greater sandhill cranes and one whooping crane in May 1976 indicates that these species occasionally stop at the study area during migrations. These stopovers are apparently linked to passage of storm fronts. This flock of cranes was probably utilizing Yellow Creek as a stopover enroute to Grays Lake National Wildlife Refuge.

Raptorial birds include the vultures, hawks, eagles, falcons, and owls. Also included in this category, due to its similar ecological role, is the common raven (Craighead and Craighead, 1969). Fourteen diurnal and four nocturnal raptors are known to use the Tract C-a area. The red-tailed hawk was frequently observed throughout the year except during late winter. The rough-legged hawk, was the most common wintering raptor. Golden eagles occurred throughout the year with the largest number observed during winter. The marsh hawk and American kestrel were common nesters during summer, but only a few individuals were recorded during the winter. The common raven was the most prevalent raptor-like species in all vegetation types. Other diurnal raptors included the turkey vulture, goshawk, sharp-shinned hawk, Cooper's hawk, Swainson's hawk, bald eagle, prairie falcon, merlin, and peregrine falcon. Nocturnal

species included the great horned owl (most common), pygmy owl, short-eared owl, and screech owl.

F. Reptiles and Amphibians - Five reptile species are known to occur in the study area, of which the sagebrush lizard is the most abundant and ubiquitous (percent relative abundance in all sampled areas = 47%). The tree lizard, eastern fence lizard, shorthorned lizard (horned toad), and western terrestrial garter snake are less common (percent relative abundances = 42, 9, 1, and 1%, respectively). Habitats showing the highest abundance and diversity of reptiles were open, southfacing slopes with ledges and rock piles for basking and shelter and with a few scattered bushes and deadfall for additional refugia. The limited amount of this habitat in the study area results in a fairly low reptile population density and diversity averaged over the entire area.

Three amphibian species, the chorus frog, Great Basin spadefoot, and tiger salamander were documented as occurring in the study area at two ponds. The area has very few habitats suitable to breeding populations of amphibians, and abundance and species diversity is low where they do occur.

G. Invertebrates - Invertebrates were sampled in five of the most common vegetation types in the study area: bottomland sagebrush, north and south slope pinyon-juniper woodlands, upland sagebrush, and mixed brush. A variety of sampling methods was used to identify the numerically abundant invertebrates within each vegetation type.

Major orders of ground dwelling invertebrates in all vegetation types throughout the season were springtails (Collembola) and mites (Acari). Of the active flying insects, the numerically dominant taxa found in all vegetation types sampled belonged to two fly families, non-biting midges (Chironomidae) and anthomyiid flies (Anthomyiidae). Each shrub, tree, and herbaceous species sampled had a complement of herbivore species, primarily from the order Homoptera. Ants (Formicidae) were the numerically dominant family found in all strat.

H. Feral Horses - Several bands of feral horses range over the study area. In contrast to the variable seasonal distribution of mule deer, feral horses are present throughout the year. The area probably supports a minimum of 135 head of feral horses. BLM personnel have estimated that 148 horses occupied the Square S and Box Elder grazing allotments (portions of which are in the study area) during the summer of 1975 (personal communication, B. Lawhorn, BLM, Meeker, 1976).

Feral horse herds ranged in all vegetation types and various bands were scattered over a large portion of the study area during the 2-year study period. Most of the horses were seen in the area bounded by Big Duck Creek, Yellow Creek, Stakes Springs Draw (up Left Fork Stake Springs Draw), and the Cathedral Bluffs, although scattered individuals or small bands were occasionally observed outside this area. Long range seasonal movements of the various herds were probably limited by barbed wire fences.

During the summer, horses foraged in mixed brush, sagebrush, bottomland meadow, and bald vegetation types. They loafed during mid-day near the same areas, often in an ecotone between two vegetation types or near large solitary trees. Many animals sought shade in pinyon-juniper stands during the hottest period of the summer day. Horses watered at springs or intermittent open water along Stake Springs, Box Elder Gulch, Corral Gulch and Big Duck Creek. If gates were left open or fences were down, horses on 84 Mesa also watered at Yellow Creek or at stock tanks in Duck Creek. Horses were also observed loafing in the bottomlands near water sources in Spruce Gulch during summer periods.

I. Domestic Livestock - Cattle distribution and dispersal in the area are determined by ranchers who own grazing allotments. Cattle are moved to higher elevations in the spring as the snowpack recedes and vegetation becomes green. In the fall, inclement weather conditions force ranchers to move cattle to rangelands at lower-elevations.

Three BLM grazing allotments have been set up in the vicinity of Tract C-a. Maps showing the areal extent of these allotments are included in

the RBOSP Terrestrial Annual Baseline Report (1976). The Reagle and Square S Allotments have been placed under Allotment Management Plans (AMP). The BLM is presently preparing an AMP for the Box Elder allotment. The AMP's provide the BLM with broader flexibility in establishing stocking rates, which depend upon year-to-year range conditions. The allotments are as follows:

- Square S Allotment - 25,920 ha (64,050 A) of BLM lands and, 4,730 ha (11,689 A) of private lands for a total of 30,651 ha (75,739 A). The grazing season is May 5 through November 25. The BLM has estimated that the carrying capacity is 5,896 animal unit months (AUM's), based on a 1941 Range Survey. Carrying capacity has been recently increased by chaining of pinyon-juniper.
- Box Elder Allotment - 10,551 ha (26,071 A) of BLM land, 894 ha (2,210 A) lands, and 797 ha (1,970 A) of private lands for a total allotment of 12,242 ha (30,251 A). The grazing season is from June 23 through October 8. The BLM has estimated that the carrying capacity is 1,517 AUM's, based on a 1973 range survey.
- Reagle Allotment - 9,613 ha (23,753 A) of BLM lands and 886 ha (2,190 A) of private lands for a total of 10,499 ha (25,943 A). The grazing season is May 3 to September 15. The BLM has estimated that the carrying capacity is 2,318 AUM's based on a 1941 range survey.

The northwest one-half of Tract C-a is in the Box Elder Allotment and the remaining portion is in the Square S Allotment. Since cattle range freely on and off the tract within the allotments, actual stocking rates in AUM's have not been calculated for Tract C-a. The BLM estimates that the carrying capacity of Tract C-a is 600 AUM's (personal communication K. Russell, BLM, Meeker, Co., November 1976).

Annual stocking rates (AUM) for Box Elder and Square S Allotments are:

Year	Square S	Box Elder
1971	Not available	1,344
1972	4,535	1,344
1973	3,759	1,344
1974	3,290	1,124
1975	4,871	1,124

J. Threatened and Endangered Species - Federal and State wildlife agencies and the Smithsonian Institution have compiled lists of plant and animal species which are "threatened", "rare", or "endangered". In determining the status of a species, the entire range of the species is considered. By Federal standards, an "endangered" species is in danger of extinction throughout all, or a significant portion, of its range; a "threatened" species is likely to become endangered within the foreseeable future throughout all, or a significant portion of its range; and a "rare" species exists as a small population within its range (USDI, 1973).

Habitats of rare plants often occur on young or unstable geologic conditions such as talus slopes, mountain tops, rock cliffs, or shale barrens. One formerly endangered plant species, the milkvetch, Astragalus lutosus (Smithsonian Institution, 1975), was found on shale outcroppings northwest of Tract C-a. The rare milkvetch is known to occur only on dry, calcareous shales at lower elevations in the drainages of the White River, Rio Blanco County, Colorado, and adjacent areas of Utah.

The peregrine falcon (Falco peregrinus anatum) is considered an endangered species by the USDI (1975). This falcon was observed four times in the Tract C-a study area during spring and summer 1975.

Two of the observations were within the tract boundaries. The number of individuals the four sightings represent is unknown because of the high mobility of this raptor. It is unlikely that peregrine falcons nest in the study area because of the lack of large cliff faces and the paucity of water (G. Craig, Chief Raptor Biologist, Colorado Division of Wildlife, personal communication, 1975).

The Colorado nesting population of the greater sandhill crane (Grus canadensis tabida) is considered endangered by the Colorado Wildlife Commission (1973). Approximately 30 greater sandhill cranes were observed in the study area. Based on observations made during spring and fall surveys of 1975, 84 Mesa and its environs may serve as migratory stopover area for cranes during adverse weather conditions. Extensive surveys were conducted to determine if these cranes were nesting along the White River but none were sighted. In May 1976, one juvenile whooping crane was also observed in the area. A discussion of greater sandhill cranes and whooping cranes is included in the avifauna section of this chapter.

2.6 AQUATIC ECOLOGY

Aquatic habitat in the study area is limited mostly to ephemeral streams and small springs and seeps. No fishery habitat occurs on tract. The nearest fish populations are 20 miles to the north in the White River. The aquatic habitats sampled during baseline studies can be classified into five types:

- Spring brook - Stations 1-4, 6-13, 15-18
- Ponds - Stations, 5, 14, 19
- Yellow Creek - Stations 20-22
- White River back channel - Stations 23, 27-29, 33
- White River open channel - Stations 24-26, 30-32, 34, 35

A total of 35 stations was sampled (Figure 7-2-12). Stations 1-4 were located in essentially small cool springs (rhenocrenes) with little macrophytic growth. Substrates at these stations are composed of loose aggregations of sand, gravel and shale pieces covered with periphyton. The other stations considered in the spring brook habitat type are similar to stations 1 through 4 and have substrates of gravel, sand and silt. The chemical consistency of their waters is also similar to that of stations 1 through 4. However, stations 10, 11, and 16 were dry

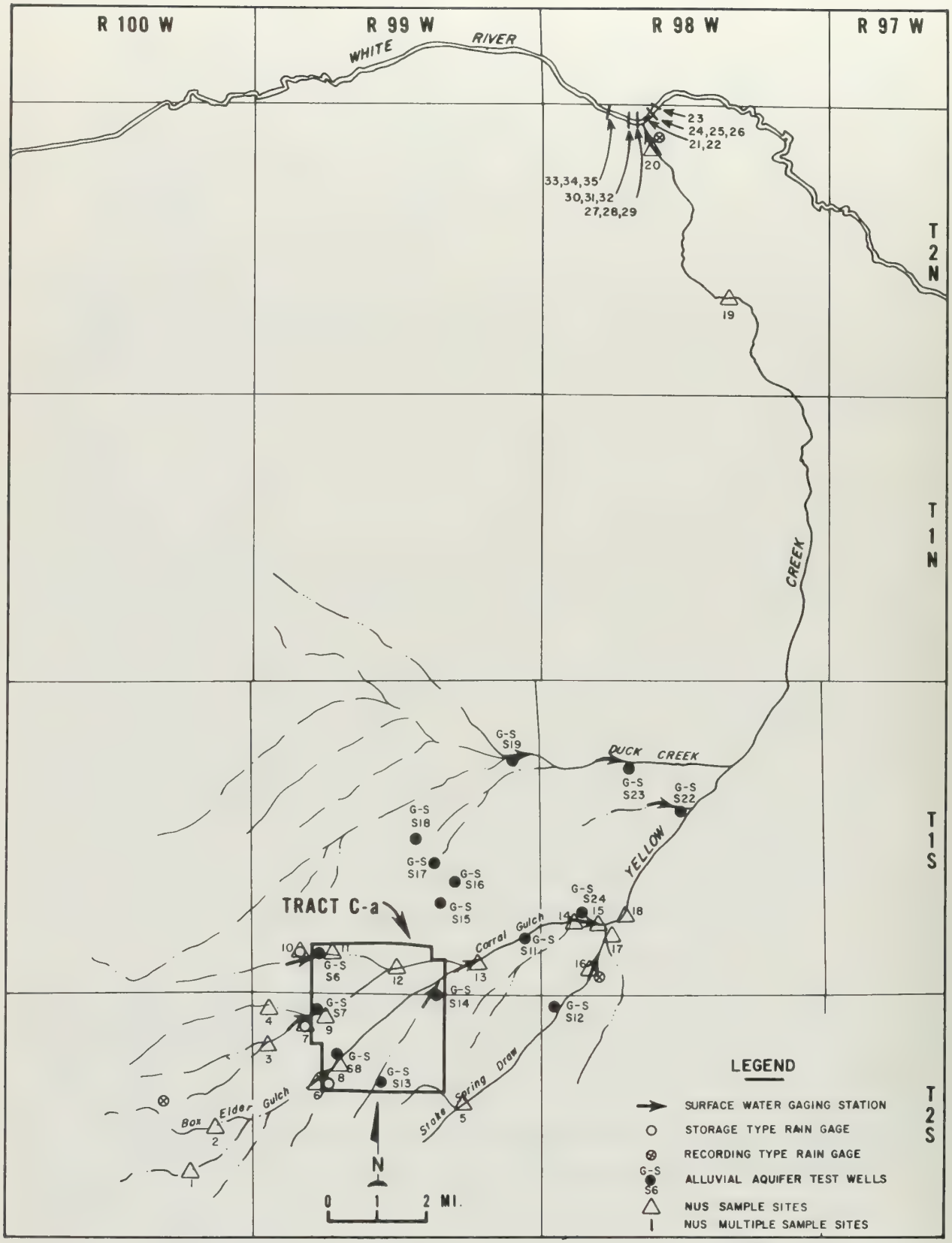

Figure 7-2-12

AQUATIC SAMPLING SITES

throughout the study period. These stations are located in large gulches which are wet only during local precipitation. Stations 7, 12, 15, 17 and 18 were dry during most of the sampling periods. When there was water at these stations, aquatic organisms were present. During the December sampling of 1974 some of the spring brook stations were frozen.

Stations 5, 14, and 19 were classified as ponds. Actually, Stations 5 and 19 are located directly downstream from weed-choked seepage areas which have many of the characteristics of ponds. Station 14 was a pond during 1974-1975 but in early spring of 1976 the structure containing the pond washed out and Station 14 eventually almost filled with sand and silt. The faunal composition at Station 14 changed considerably because of this alteration.

Stations 20, 12, and 22 were located on Yellow Creek. These stations are very similar and all are within 1000 m of each other along the lower end of Yellow Creek near its confluence with the White River.

Station 23, 27-29, and 33 were classified as the back channel stations. They are all located in side channels of the White River where the water velocity is much lower than in the main river channel. Substrates in this habitat type are essentially heterogeneous. The major substrate is cobble with rubble and gravel. During low flow periods of the year siltation is heavy.

Stations 24-26, 30-32, 34 and 35 comprised the open channel habitat type. These stations are found in the main channel of the White River.

Aquatic biota data were collected from surface waters of Tract C-a, Yellow Creek and the confluence of Yellow Creek and the White River from October 1974 through September 1976. Studies were designed to inventory the aquatic biota of the area and to determine the baseline characteristics of aquatic resources in the vicinity. Aquatic biota studies were conducted in conjunction with extensive surface water and groundwater physio-chemical studies. Species composition, relative abundance and distribution

of phytoplankton, zooplankton, macrophytes, periphyton, benthos and fish were determined. In addition, productivity studies were conducted for periphyton and age, growth, condition and reproduction studies were conducted on fishes of the White River and Yellow Creek. Complete descriptions of sampling methods employed appear in RBOSP Aquatic Annual Baseline Report (1976).

Species composition, diversity and relative abundance for each of the biotic groups was compared for each year of baseline studies and among habitat types. Some fluctuations were noted but, for the most part, these parameters remained stable throughout the study period.

Species composition of phytoplankton was generally similar among habitats (spring brook, pond, creek, river); but dominant taxa varied distinctly.

Rotifers were the most abundant zooplankton organisms, and occured in largest numbers in the pond habitats. Protozoans were the second most abundant plankters but largest concentrations occurred in the river habitats. These variations reflect the importance of stream velocity in influencing faunal distribution. Protozoan numbers increased with velocity, rotifer numbers declined. Rotifers tend to be destroyed by high turbulence.

Periphyton communities in the pond habitats were more diverse than those in the spring brooks, similar to those in creek habitats, and less diverse than those in the river habitats as indicated by diversity indices. Mean organic weights of periphyton were also higher in the river habitats than in other areas.

Many benthic taxa are found in the White River and Yellow Creek drainages. Substrate characteristics appear to be of major importance in determining species diversities. The number of taxa was lower in the creek habitats than at other stations. The heterogeneous substrate of the river habitats tended to increase benthic diversity. Physico-chemical variations

appear to influence benthic populations in the various habitat types. Many benthic organisms from the area reflected special adaptations for food gathering which have allowed them to survive within the somewhat adverse conditions of Yellow Creek and the White River.

Only 15 species of fish were collected throughout the 2-year baseline study. All specimens were taken from Yellow Creek and White River, since no fishes occur on tract. Most fish were recovered from the White River rather than from Yellow Creek. The speckled dace was the most abundant species collected. No threatened or endangered species were recovered from the study area. In general the distribution of fish catches was similar for both years. Spawning was earlier in 1976 than in 1975. This was apparently related to a shorter snow melt runoff period in 1976.

Baseline studies showed that phytoplankton, zooplankton and macrophytes occupy relatively unimportant roles in the aquatic ecosystem of the area. Periphyton are the major primary producers, and give rise to a significant portion of the free-floating planktonic organisms. Benthic organisms are the primary aquatic consumers on the tract in the absence of fish species. Fishes occur only in Yellow Creek and White River stations, most on-tract surface water bodies are ephemeral. Macrophytes were limited to a few pond habitats.

2.7 CULTURAL RESOURCES

Artifacts recovered from the Tract C-a and vicinity indicate there were at least four periods of occupation of the area; an Archaic period perhaps beginning as early as 7000 to 600 B.C.; followed by the Fremont Culture that began after 500 A.D., the Ute, whose beginnings are not presently established; and, finally, the 19th Century Anglos. The socio-political organization of early man in the area (Archaic) was probably uncomplicated. Exploitation was accomplished most efficiently by the extended family unit. The early people must have possessed

considerable knowledge of natural history, seasonal patterns of game movements, and ripening times of various plants, as these were the criteria that would have dictated the movement of the group. Exploitation patterns indicate that deer, elk, plants, fish, insects, waterfowl, rodents, and reptiles were eaten. Material culture was geared to frequent changes in location. Flexible containers of hide or basketry were used instead of ceramics. Other types of equipment were practical and portable. Clothing was minimal and housing constructed only when a subsistence item was plentiful enough to support the group in one place for a period of time. Caves or overhangs were used when they occurred. Most Archaic artifacts found in the area were projectile points. This occupation could have extended back several thousand years, but this cannot be positively confirmed from limited surface materials recovered during the survey.

As the Archaic pattern faded, it was replaced by the Fremont Culture. In general, this transition involved expansion of agricultural practices and use of pottery. However, evidence for Tract C-a indicates that it is unlikely that agriculture was practiced in the immediate vicinity. Artifacts of the Fremont era are more refined than from the Archaic period. Projectile points are smaller and shaped differently.

Introduction of the Ute culture (as indicated by presence of wickiups) into the area cannot be positively placed in time. It may have occurred as an extension of the Fremont period with the advancement of use of horses and European goods.

The possible discovery of a fragment from a Paleo Indian projectile point could mean that man was utilizing the area at a much earlier data than previously expected.

The primary historical factor leading to the settlement of the study area by Euro-Americans appears to have been the cattle industry. There is no evidence that dry land farming was practiced, and there is no mining industry prior to the current speculation in oil shale. Utilization

of the area by Euro Americans apparently falls into three periods:

- Period I - Initial Homesteading (ca. 1885 - 1895)
- Period II - Second Homesteading (ca. 1918 - 1930)
- Period III - Residual Exploitation (ca. 1950 -)

The first period is represented in the study area by three homestead sites, including 84 Ranch. Homesteading during this period apparently resulted from man's attempt to utilize even marginal grazing lands for the production of cattle as land became increasingly scarce. These homesteads were apparently occupied for only a short while. Complete descriptions of these homesteads appear in the RBOSP Cultural Resource Survey Report (1975).

Period II is represented by seven homestead sites and a school. This renewed homesteading period was probably generated by the passage of two new homestead acts - the "Enlarged Homestead Act of 1909" and the "Stock-Raising Homestead Act of 1916". Both these acts enlarged the sizes of permissible homestead plots in an effort to satisfy western cattle interests. The sites indicative of this period have outbuildings and other improvements which suggest more permanent occupation than during Period I. Use of 84 Ranch continued through this period, but other Period I homesteads were abandoned before Period II began. Both Period II homesteads and 84 Ranch were apparently abandoned prior to 1950, and most were probably forced out during the Great Depression of the 1930's.

Period III was marked by intermittent use of the area by cattle ranchers living outside the immediate vicinity. Previously abandoned homesteads were sometimes used as "cow camps", especially 84 Ranch. During this period wild horses were sometimes captured in horse traps constructed of pinyon-juniper limbs. Four of these horse traps remain in the area. Horse trapping probably continued until the passage of the Wild Horse and Burro Act of 1971 which made such activities illegal.

Paleo-finds were examined from 9 sites in the vicinity of Tract C-a. These finds included fossil fragments of a unintathere vertebra, a

turtle carapace, and a mammal from the Eocene period; fragments of petrified wood, (period not identifiable); and non-fossilized deer and bison bone.

All of these finds are common in Eocene sediments of the entire Rocky Mountain area and as such do not represent significant Paleo-finds. These finds were found lying loose and could have been transported in the area by early man.

Two archaeological sites in the study area were considered to be of National Historic Register significance (see Section 6, Chapter 12 - Protection of Objects of Scientific and Historic Interest).

CHAPTER 3
AIR

The development of Tract C-a will increase the pollutant concentrations in the ambient air at the site and in the site region. The present levels of regulated gaseous pollutants such as sulfur oxides, carbon monoxide, and hydrogen sulfide are extremely low, ranging from concentrations of a few parts per billion of sulfur compounds and nitrogen oxides to one part per million or less of carbon monoxide. Mean values of suspended particulate concentration are also very low, being in the range of 20 mg/m^3. Only oxidant levels (measured as ozone) and non-methane hydrocarbon concentrations are elevated, and there is no local or regional public or commercial source of either of these pollutants.

Development of Tract C-a will necessarily involve vehicular traffic, construction activity, combustion of fossil fuel for energy requirements, processed exhaust gases, mining operations and ventilation, transport and crushing raw shale, above ground retorting emissions, and the transport and storage of processed shale. Each of these activities, among others, has a potential for the release of gaseous or particulate pollutants into the ambient air where they will have a measurable effect on ambient air quality on or surrounding the site. Because of the very low concentration levels that currently exist, even a small release of any pollutant will cause a large percentage change in concentration.

The low precipitation on the site during the 2 baseline data years resulted in extremely dry surface conditions for much of the time. Suspended particulate measurments taken off-site occasionally exceeded State and Federal standards. A close examination shows that elevated particulate levels occur on weekends, holidays, and hunting season when there is uncontrolled public vehicular traffic on site. There are no paved roadways on the tract. If during the initial development of the tract for the Modular Phase there is an appreciable amount of vehicular

traffic during dry conditions, considerable surface released particulate matter will be generated by traffic on unpaved roads.

The increased vehicular traffic will also contribute carbon monoxide, nitrogen oxides, and hydrocarbon emissions. The amount of nitrogen oxides and hydrocarbons will be small compared to other sources to be located on the tract, or already present in the ambient air originating from natural sources.

Mining operations, transport of raw shale, crushing during the Commercial Phase and the disposal of processed shale are potential pollutant sources for particulates and gases released during underground mining. All of these sources are at ground level and will affect ambient air concentrations on the site.

During the Modular Development Phase there will be the requirements for operation of a steam boiler fired by fossil fuel. Waste retort gases will be incinerated in a thermal oxidizer prior to their release to the atmosphere. Both of these sources will be ducted to stacks approximately 100 meters high. The stack location or locations will be on a high ridge near the center of the tract to facilitate dispersion of effluents. The dispersion of emissions will be into the atmospheric regime above the higher elevations of the tract and will not be subject to the highly variable surface wind patterns. The dispersion of effluents from the stacks has been modeled mathematically and is discussed in detail in Section 6, Chapter 5, part 7.

The Commercial Phase will include the installation of an electrical power generation facility, the simultaneous operation of several in situ retorts, and the addition of aboveground retorts of the TOSCO II type for the recovery of oil from shale mined from the in situ retorts and other underground workings. The electric power generation plant will consist of multiple gas combustion turbines which will result in the emission of nitrogen oxides. The retorting operation will result in the emission of sulfur and nitrogen oxides and hydrocarbons. All of

these emissions will be ducted to stacks on high ground on the tract. The dispersion of effluents from the stacks has been modeled mathematically and is discussed in detail in Section 6, Chapter 5, part 7.

None of the emissions released from the facilities located on the tract are expected to result in ground level concentrations which will exceed Federal ambient air quality standards. The increase in ambient air concentrations is expected to be less than is permissible for Class II classified regions under control of Federal no significant deterioration regulations. Colorado Category I increment for SO_2 is expected to be exceeded.

CHAPTER 4
TERRESTRIAL ASSESSMENT

Most of the terrestrial impacts of oil shale production by Tract C-a development would occur on or in the vicinity of Tract C-a. An assessment of potential impacts was conducted by means of a cause-effect matrix analysis (Leopold et al., 1971), and was based on mining plans, pertinent literature, and extensive ecological data collected during the baseline studies.

Direct impacts resulting from the Tract C-a oil shale development include:

- Physical destruction or damage of habitat and wildlife from construction.
- Loss of habitat available for wildlife use by fencing or other obstruction.
- Damage to habitat by airborne effluents (gases, dust).
- Wildlife stresses caused by noise or human presence.
- Loss of water from mine dewatering.
- Potential contamination of ground and surface waters.

Indirect impacts, related to increased human presence, include:

- Increased recreational use.
- Increased road kills.
- Increased human harassment of wildlife.

An assessment or evaluation of these impacts for the Modular and Commercial Phases of development and operation follows.

4.1 MODULAR DEVELOPMENT PHASE

A. Construction Impacts

1. Source - During the Modular Development Phase, construction will disturb about 471 acres (Table 7-4-1). Mine facilities and corridors (e.g., pipeline, haul and access roads, and powerline) will permanently occupy 44 acres. It is anticipated that a highway will be built by the State of Colorado to provide access to Tract C-a from Rangely. Fugitive dust and noise will result from the operation of construction machinery.

2. Mitigation Measures - Surface disturbances will be minimized by using existing access roads when possible and by constructing additional access roads only when necessary. Powerline construction design will prevent electrocution of raptors. The pipeline for the dewatering system will be buried and therefore will not obstruct deer movement.

Mechanical and vegetative erosion control measures (Section 6, Chapter 8) will be used to minimize soil loss and sedimentation to Box Elder Gulch and Corral Gulch. Excessive fugitive dust problems may necessitate periodic watering. Habitat disturbance and loss will be mitigated by modifying adjacent areas to improve their value for certain species of wildlife. Corridor areas will be revegetated as outlined in Section 6, Chapter 8.4, within 1 year after construction activities are completed. The revegetated areas along the powerlines will improve forage availability while maintaining shelter provided by adjacent mature habitat.

3. Impact Assessment - The 34 acres required for service shafts and compressors contain pinyon-juniper and upland sagebrush. Small mammals (e.g., deer mice and chipmunks) and songbirds might be adversely affected by the disturbance. Although some small mammals will be destroyed or displaced and some potential nesting habitat for the mountain bluebird and vesper sparrow will be lost, the losses will not be critical to the animal populations on tract.

Table 7-4-1

APPROXIMATE ESTIMATE OF THE EXTENT (ACRES) OF HABITATS DISTURBED AS A RESULT OF RBOSP CONSTRUCTION ACTIVITIES DURING THE MODULAR DEVELOPMENT PHASE AND COMMERCIAL PHASES

Construction Area	Mixed Brush	Pinyon-Juniper	Pinyon-Juniper Mixed Brush	Pinyon-Juniper Sagebrush	Upland Sagebrush	Bottomland Sagebrush	Rabbit Brush	Grease Wood	Shadscale		Total
Modular Development Phase											
Mine & Plant Site	14		2	6	12						34
Run of Mine Disposal Area			14	28	23						65
Primary Crushed Ore Disposal Area	1	23	9	77	150						260
Corridors	28		46	2	17	6			13		112
Totals	43	23	71	113	202	6			13	Subtotal	471
Commercial Phase											
Mine & Plant Site	34	5	46	118	41						244
Processed Shale Disposal Pile	56	4	152	164	403	86			15		880
Corridors	15	2	69	11	8	27	18	5	9		164
Totals	105	11	267	293	452	113	18	5	24	Subtotal	1,288
										Total	1,759

Of the 112 acres disturbed for corridor construction, 92 acres will be revegetated according to the RBOSP revegetation plan (Section 6, Chapter 8.4) and 20 acres will be permanently lost. This loss in habitat is too small a percentage of the 5,100 acres of the site to significantly affect wildlife populations in the area.

An assessment of the impacts from construction of the utility and transportation corridor between Rangely and Tract C-a was conducted by BLM (USDI, 1975). The effects on wildlife of vehicle use along this corridor will be discussed later under "Manpower Impacts."

The noise and fugitive dust caused by machinery operation may affect animal relative abundance and distribution in adjacent areas, but this disturbance to animal populations will be a short-term impact. Although the potential for erosion in the area is moderate to critical (RBOSP Progress Report 10, 1977), erosion control measures will be employed to minimize any soil loss and thereby prevent adverse impacts.

B. Mining Impacts

1. Source - During underground mining, overburden and raw shale ore will be excavated to prepare the room and pillar configuration required for the MIS process. Blasting will be necessary to rubblize the oil shale to produce voids necessary for underground retorting. Dewatering will be conducted prior to mining operations. The details of the dewatering plans, mitigation, and impact assessment are discussed in Section 7, Chapter 6.

2. Mitigation Measures - Vented mine air and powder gases will be scrubbed to meet state and federal EPA emission standards (see Air Quality Control Plan, Section 6, Chapter 5). The noise and seismic shocks produced by the blasting will be mitigated naturally because blasting will occur underground.

If dewatering causes significant changes in stream flow, a water augmentation program will be initiated as required by the Colorado Water Law.

3. Impact Assessment - Anticipated gaseous emissions (e.g., vented mine air and gases) are below levels that might affect terrestrial vegetation and fauna. Blasting will produce minor noise levels and seismic shocks (less than one on the Richter scale) which should not affect animal distribution and abundance on the tract.

Effects of dewatering will be monitored. If major springs and seeps in the tract vicinity are dried up, mitigation measures will be initiated and therefore any adverse impacts would be short-term.

C. Operational Impacts

1. Source - During the Modular Development Phase, all shale oil will be produced by underground retorting. By-products of processing include water and low-BTU gas. Ventilation exhaust fans associated with underground operations will produce noise. A thermal oxidizer will be used to burn off-gas from retorts during Modular Development.

2. Mitigation Measures - Incineration of the low-BTU product gas during the Modular Development Phase will reduce emissions to meet Federal and State standards. Containment structures housing ventilation fans will reduce the noise levels to meet OSHA standards. Excess MIS retort water will be incinerated.

3. Impact Assessment - Burning in the underground retorts should have no direct impact on the terrestrial system. Incineration of the low-BTU gas will reduce air emissions to required levels such that the effect of air emission on terrestrial communities should be negligible (RBOSP, 1977).

D. Storage and Transfer Impacts

1. Source - The storage of fuel, chemicals, explosives, machinery, and product oil may result in accidental spills or releases. Transfer during Modular Development Phase will be done primarily by trucks. Transfer of primary crushed ore after 1984 will be accomplished by conveyor belts to the southwest section of the tract. The water removed from the mine area by dewatering will be transferred to the reinjection locations by pipeline. Surface soil stripped from the disposal area prior to disposal will be stockpiled adjacent to those areas (see Disposal Impacts below).

2. Mitigation Measures - Storage facilities used to store toxic chemicals will be diked to prevent contamination should a spill occur (Section 6, Chapter 7). Explosives will be stored according to safety regulations (Section 6, Chapter 2). The dewatering pipeline will be buried will be revegetated within 1 year after construction. The conveyor belts will be enclosed to reduce dust. Surface soil stockpiles will be mulched or revegetated using a quick-growing annual to prevent erosion and fugitive dust.

3. Impact Assessment - Potential adverse impacts (e.g., loss of vegetation or contamination of soils) will be eliminated by successful execution of the appropriate control plans.

E. Disposal Impacts

1. Source - Product water, mine seepage water, escape gas, blasted or raw shale ore, and trash produced during the Modular Development Phase are potential sources of impact. Gas may escape from the mine area if subsidence occurs. Some of the waste rock and raw shale ore (38,000 ton/day) will be used for the construction of haul roads and for improving existing roads; the remainder will be deposited on tract in the run-of-mine ore disposal area or the development ore disposal pile.

Disposal of approximately 3 million yards of rock and raw shale ore will necessitate the clearing of approximately 325 acres. All surface soils will be stripped from the disposal area prior to disposal of the rock and stockpiled.

2. Mitigation Measures - The run-of-mine and development ore (primary crushed rock) disposal areas (Figure 7-1-1) will be graded, covered with 12 inches of the surface soils previously stockpiled, and revegetated as described in the revegetation plan (Section 6, Chapter 8.4). The disposal areas will be revegetated with a mixture of grasses, forbs, and shrubs which should provide a variety of forage and browse plant species. Temporary loss of wildlife habitat will be mitigated by enhancement of adjacent areas according to the Fish and Wildlife Management Plan (Section 6, Chapter 11). The surface soil stockpile may be temporarily revegetated with a quick-growing annual if fugitive dust problems become apparent.

The MIS retort water will be incinerated. Mine seepage water will be treated, and that not consumed will be reinjected. RBOSP will install containment structures to prevent discharge resulting from runoff from small-scale storms (see Section 6, Chapter 6).

3. Impact Assessment - Since all MIS retort water will be incinerated and mine seepage water will be treated for use or reinjection, no terrestrial impacts should result.

The potential for, or characteristics and quantities of, escape gas are not known at this time. Escaped gases, should they occur, will be monitored. If adverse emissions occur, they will be temporary and very local in area of influence. Prevention of subsidence, if it occurs, will eliminate the escape route for such gases and therefore no impacts should occur.

Pinyon-juniper habitat types and upland sagebrush will be the primary vegetation types affected by the disposal of overburden rock and raw

shale ore (Table 7-4-1). This habitat loss will reduce the amount of forage and browse and cover available to wildlife. Baseline studies indicated that the range conditions in the study area were fair to poor in pinyon-juniper and fair in sagebrush. However, browse conditions within these habitats were generally considered good (RBOSP Final Environmental Baseline Report, 1977). The temporary loss of forage and browse should not be significant since the habitat modification program will improve the quality of forage and browse in adjacent areas.

Mule deer, small mammals, and songbirds will be affected by the loss of pinyon-juniper and upland sagebrush. Mule deer may alter their movement through the area to avoid the disposal piles. Most small mammals (e.g., least chipmunk and deer mouse) inhabiting the area will be destroyed. Breeding birds (e.g., mourning dove, mountain bluebird, mountain chickadee, vesper sparrow, and Brewer's sparrow) will suffer a loss of nesting habitat.

F. Manpower Impacts

1. Source - The construction and operation of mining activities on Tract C-a will require a work force of 250 to 400 persons. It is expected that most personnel will commute from Rangely. In addition, some will commute from Meeker, Rifle, or elsewhere in the general vicinity of the Piceance Creek basin.

2. Mitigation Measures - During the 2-year period prior to submission of this DDP, RBOSP cooperated with the town of Rangely in the preparation of a master plan (GOREDCO, 1976). This master plan outlines a practical sequence of developments which would minimize, or possibly eliminate, the potential adverse impacts which could result from uncontrolled growth of Rangely due to oil shale development.

RBOSP will attempt to mitigate any adverse secondary impacts by public relations techniques (e.g., publication of a brochure). Such a brochure would inform RBOSP employees and other interested persons of the valuable

natural resources in the Piceance Creek basin and the methods to protect such resources. Additional human control measures are discussed in Section 6, Chapter 11.

3. Impact Assessment - The presence of 250 to 400 employees on Tract C-a and of periodic visitors and their pets will disturb local wildlife populations. The extent of the disturbance will depend on the behavior of the people involved.

The disturbance that would result from 250 to 400 employees commuting and working in a previously remote area is difficult to estimate. Increased accessiblility to remote areas is likely to result in increased recreational use of the tract and adjacent areas. Off-road vehicle use poses the greatest potential for adverse impact on vegetation. The extent of damage to wildlife food and cover and increased soil erosion will be related to the amount of off-road vehicle use.

New road systems will probably increase the amount of hunting (both legal and illegal) and the number of deer-vehicle collisions on and near the tract. Mule deer and raptors are vulnerable to illegal hunting; mule deer road kills are likely to increase substantially. Woodard (1976) reported 1,527 big game-vehicle accidents in Colorado in 1975, primarily along Interstate 70. No deer-vehicle collision data are available for the Piceance Creek basin and the loss that would result from traffic associated with Tract C-a development cannot be estimated.

G. Subsidence

1. Source - Underground access corridors and voids resulting from the room and pillar design of the MIS development will remain after RBOSP mining activities are completed. Subsidence may occur as changes in the geologic strata cause sinking or cracking.

2. Mitigation Measures - RBOSP is investigating several alternatives to mitigate and prevent subsidence (Section 8, Chapter 8). These

alternatives include backfilling the abandoned retorts with a slurry of processed shale, filling cracks or depressions with rock material, or fencing subsidence areas to prevent injury to man or wildlife.

3. Impact Assessment - If mitigative measures to prevent or minimize subsidence are successful, the terrestrial system will not be affected. In the event that subsidence does occur, subsidence of 0 to 60 feet could occur and could adversely affect the biota if large surface cracks develop. Subsidence will be monitored by RBOSP and appropriate measures will be taken to eliminate substantial subsidence.

H. Environmental Actions

1. Source - During the Modular Development Phase, ecologists will monitor the environment to assess the impacts of development and the results of the modification and revegetation programs.

2. Mitigation Measures - The environmental programs planned for the Modular Development Phase are, in part, mitigative plans. The monitoring and mitigation programs will be conducted according to performance standards which should insure successful habitat modification and revegetation and result in improved habitat for some species of wildlife.

3. Impact Assessment - The human activity associated with field collection of monitoring data will cause negligible impacts. These disturbances will occur for several days; no biota will be affected permanently. The habitat modification program is expected to increase forage and browse productivity for wildlife. The duration of this impact will depend on the initial success in removing and/or converting less suitable habitat and replacing it with a more desirable plant community, and the rate of species invasion from adjacent habitat. The results of the habitat modification program will be monitored (Section 6, Chapter 11).

The impacts of the revegetation program will be greater in areal extent and time. Revegetation of the disposal area on tract will continue over a 30-year period. Revegetation will stabilize the area and provide diverse forage and browse. Although primary succession will be rapid due to the direct planting of species, secondary succession will be more gradual and will require decades. Therefore, the effects will be long-term but should not be considered adverse. The revegetated areas may be initially more suitable to different numbers and kinds of fauna than are current habitats. Introduction of a diverse vegetation could ultimately be beneficial to some wildlife by providing a greater variety of food and cover. The revegetated areas will be monitored to determine if the program is successful (Section 8, Chapter 7).

4.2 COMMERCIAL PHASE

A. Construction Impacts

1. Source - During the Commercial Phase, surface mine facilities will be expanded in the vicinity of the Modular Development Phase production and service shaft. A large processing complex, to be built on Airplane Ridge, will include three TOSCO II surface retorts, a gas treatment area, a switchyard, and ancillary facilities. These facilities will occupy approximately 244 acres.

2. Mitigation Measures - To minimize the potential for erosion, clearing will be confined to the minimum area necessary for a particular stage of development. The erosion hazard on Airplane Ridge is considered moderate to severe (RBOSP Progress Report 10, 1977). Erosion control plans (Section 6, Chapter 8) will be implemented throughout the construction period. Both mechanical (e.g., construction of culverts or dikes) and vegetative (e.g., mulches) erosion control methods will be used to prevent any long-term impacts.

Dust problems created by construction will be controlled by water or chemical treatments.

The loss of habitat will be mitigated by modifying adjacent habitat to provide additional forage and browse for wildlife (Section 6, Chapter 11). After construction, disturbed areas that are not occupied by facilities will be revegetated (Section 6, Chapter 8.4) to restore vegetation and wildlife habitat and to stabilize soils.

3. Impact Assessment - The 244 acres of vegetation and wildlife habitat lost by construction of mining and processing facilities will include mixed brush (34 acres), pinyon-juniper associations (118 acres), and upland sagebrush (41 acres) (Table 7-4-1). Aerial censuses found more mule deer on Airplane Ridge than on any other portion of the tract (RBOSP Progress Report 10, 1977). The quality of forage and browse on Tract C-a has been previously discussed (See Section 6, Chapter 11). Since Tract C-a is transitional habitat which is used by deer during spring and fall, and possibly during mild winters, the loss of 244 acres should not critically affect the deer population in the Piceance Creek basin. The loss of habitat may force deer to modify their daily movements and migration patterns in the vicinity of the mining facilities.

Small mammals and songbirds which also use the area will be lost. Rodents (e.g., least chipmunk and deer mouse) and Nuttall's cottontail will probably be destroyed during construction or will be forced into adjacent habitats where they may not survive. The importance of small mammal populations as food for coyotes, raptors, and other predators is difficult to assess. Coyotes and raptors (e.g., redtailed hawk, American kestrel, great horned owl) are present in low to moderate numbers in the vicinity of the tract. The tract is not an important feeding area for eagles or the peregrine falcon. The area to be cleared may be large enough to influence local predator distribution but it is probably not large enough to change predator populations in the vicinity of the tract.

To mitigate adverse effects of construction activities, RBOSP will improve the ability of adjacent habitats (Section 6, Chapter 11) to support wildlife.

Competition between deer, horses, and cattle for food will probably increase on areas adjacent to construction, but substantial damage to important forage and browse plants is not expected.

No adverse impacts should result from erosion because the Erosion Control Plans (Section 6, Chapter 8) will be implemented.

Fugitive dust from construction activities and from the use of haul roads could affect vegetation adjacent to roads and the construction site. This impact should not be significant since excessive dust will be controlled by water or chemical treatments.

B. Mining Impacts

1. Source - During mining, raw shale ore will be excavated in preparation of the underground retorts. This raw shale ore will be transferred to the processing complex for surface retorting. Blasting will be frequent and mine dewatering will be continuous, as described earlier. Air and powder gases from rubblizing in the mine will be vented to the surface.

2. Mitigation Measures - The mitigation measures for mining impacts during the Commercial Phase are similar to those discussed for the Modular Development Phase.

3. Impact Assessment - More mine air and gases will be vented than during the Modular Development Phase, but these emissions will be below levels expected to affect terrestrial fauna and vegetation. Blasting will produce minor surface noise and seismic shocks whose magnitude will register less than one on the Richter scale. This noise and the minor seismic shocks should not adversely affect animal distribution or abundance in the vicinity of the tract.

Impacts to terrestrial flora and fauna from dewatering should be minor and short term since RBOSP will mitigate the effect of any body of water which is dried up as a result of mine dewatering activities.

C. Operational Impacts

1. Source - During the Commercial Phase, shale oil will be produced by underground retorting and TOSCO II surface retorting. Treated low BTU gas will be burned in gas turbines to produce electricity. An evaporative cooling tower will be operated for the TOSCO II retorts and surface crushers will be used to crush shale ore for processing in the TOSCO retorts. Ventilation fans will generate noise.

2. Mitigation Measures - Gaseous and particulate emissions from the TOSCO II retort and gas turbine power generation system will be treated prior to release to the atmosphere according to the Air Quality Control Plan (Section 6, Chapter 5). The resultant air quality will comply with applicable State and Federal regulations. Effects of any reduction in air quality to the terrestrial system will be monitored (Section 8, Chapters 2 and 4). Noise from the compressors, crushers, and loading facilities will be suppressed by construction of appropriate enclosures for these noise sources where feasible. The cumulative noise levels produced by these operations will not exceed OSHA standards.

Dust from the crushing operations will be suppressed.

3. Impact Assessment - Underground retorting will have no impact on terrestrial biota. Biological effects from the particulate and gaseous emissions of the TOSCO II processing facilities and cooling towers may result. These emissions will reach a maximum during commercial operations (Tables 3-2-1 and 3-3-6, Section 3, Chapters 2 and 3).

SO_2 emissions present a potential impact to vegetation in the vicinity of the facility. Several reviews have been published concerning the response of vegetation to SO_2 (Thomas and Hendricks, 1956; Thomas, 1968; Barrett and Benedict, 1970; Jones, Weber, and Balsillie, 1974). Injury to vegetation may result in visible markings or symptoms (Barrett and Benedict, 1970) or as physiological or growth responses (Guderian and

Stratmann, 1962; Johnson and Hevly, 1973). Damage may also become apparent in the response of plant communities to pollutants (Treshow, 1968; Woodwell, 1970; Eastmond, 1971).

Chronic damage may result either from rapid accumulation of sulfite ions at sublethal concentrations during short-term exposure to high SO_2 concentrations, or from long-term accumulation of sulfate ions. In either case, the tissue may continue to function at a reduced level of efficiency proportional to the degree of tissue damage. Acute injury results from rapid accumulation of toxic ions. This injury appears as areas of dead tissue which, at first, have a gray-green watersoaked appearance and later turn a bleached ivory or reddish-brown color upon drying (Barrett and Benedict, 1970).

Plant communities may be altered in response to selective pressure from air pollutants, such as SO_2. Should injury to sensitive species occur, species composition could be altered to favor less sensitive species. These alterations may be particularly important in watersheds in the arid west (Treshow, 1968) and in rangeland and wildlife habitat where key browse and forage species could be affected.

Considerable information is available concerning the effects of SO_2 on field crops. Far less is known about the response of native species occurring in the Piceance Creek basin. In a series of field and laboratory tests of 53 plant species, many of which are found in the study area, it was concluded that "it takes relatively high concentrations of sulfur dioxide to damage the most common species native to the southwest region" (Lamb, 1972). In laboratory tests, at SO_2 concentrations of 0.5-1.0 ppm and an exposure time of 3 hours (at or near secondary Federal standards), Indian ricegrass, a common grass in the Tract C-a study area, showed definite evidence of pollution damage (Lamb, 1972; Jonson and Hevly, 1973).

A species of mountain mahogany, closely related to the one occurring on Tract C-a, also showed signs of damage (Lamb, 1972). Several other

species common to the area, including big sagebrush, shadscale, inland saltgrass, and scarlet globemallow, have been damaged by SO_2 concentrations in the range of 1.0-2.0 ppm for a duration of 3 hours.

Recent work in sagebrush, pinyon-juniper and aspen communities has identified the relative sensitivities of species similar to those found in the Piceance Creek basin (Hill et al., 1974). Species found to be most sensitive in field SO_2 fumigations include globemallow, Indian ricegrass, evening primrose, Utah serviceberry, snowberry, and scarlet gilia. Grama grass, pinyon pine, and juniper are relatively resistant to SO_2. Aspen is highly sensitive to even low concentrations of SO_2 (Lowan et al., 1972), and Douglas fir is one of the most SO_2 sensitive conifer species. Aspen and Douglas fir are more sensitive to SO_2 fumigation than are most native or crop species (Treshow, 1970; Lowan et al., 1972).

An additional uncertainty which makes the prediction of effects by SO_2 on vegetation difficult is the possibility of interactions (synergism) between SO_2 and other gaseous emissions (Heck, 1968; Menser and Heggestad, 1966). No evidence of SO_2/NO_x synergism was found in fumigation studies involving species similar to those found in the Piceance Creek basin (Hill et al., 1974).

Modeling results based on emissions from TOSCO II stacks and other sources have shown that the maximum annual mean concentration of SO_2 will be 2.7 $\mu g/m^3$ during the Commercial Phase. Species indicated to be relatively sensitive to SO_2 e.g., Indian ricegrass (Hill et al., 1974) are not expected to be injured at this level. The maximum annual mean concentration of NO_x is not expected to exceed 13.6 $\mu g/m^3$ and at these levels injury to vegetation is not expected to occur.

Particulate emissions are second to gaseous emissions in their potential for affecting areas around an emission source. While there are no standards governing the emission of the trace elements that accompany stack gases or salt drift from cooling towers and spent shale moisturizers,

both gases and salt drift should be recognized as being potentially damaging. It is not expected that trace elements (e.g., arsenic, fluoride, mercury, selenium) will be emitted from the processing facilities (Section 3, Chapter 2).

Potential effects of such trace elements in soils and on vegetation have been discussed in detail in RBOSP Progress Report 9 (1977). Since no emissions of trace element are projected, no impact on vegetation and animals is expected. Potential trace element emissions will be monitored (Section 8, Chapters 2 and 4) since information on the trace elements contained in oil shale and the percentages that will be vented with stack gases is limited.

The cooling tower will produce salt drift which could affect the soil salinity and thus the growth and distribution of vegetation. Salt drift from the cooling tower was predicted on the basis of 1) a diffusion equation model which predicts that highest rates of salt accumulation will occur close to the cooling tower and 2) a trajectory model which predicts that the rates will be lower and that accumulation will occur further from the tower than with the diffusion model (Section 6, Chapter 5.7). It is expected that the actual pattern will be somewhere between the two.

Salt drift may affect local vegetation through direct deposition of aerosol droplets on leaf surfaces or through effects on soil salinity; both avenues of effect may ultimately produce the same results, i.e., a change in species composition or, in extreme cases, a complete loss of plant cover within affected areas. Sensitivity to foliar salt deposition varies widely among species and is strongly dependent on relative humidity (McCune et al., 1974; Moser, 1975). High humidity tends to increase the injury associated with a given aerosol concentration. Humidity is relatively low on Tract C-a. Morphological differences may also account for the vast differences in the sensitivity of different species to salt.

Many plant species in the Piceance Creek basin are adapted to saline conditions (halophytic species) and exhibit substantial levels of sodium and chloride in leaf and stem tissues. It is not likely that such species will be adversely affected by moderate salt accumulation from cooling tower drift.

Assuming that all salts deposited on the soil surface will be evenly distributed in the uppermost 35 cm (14 inches) of the soil (no salts lost in surface runoff or by soil percolation deeper than 14 inches), a deposition rate of 100 $g/m^2/yr$ (at 150 m NNE of tower) would require about 7 year for salt concentrations to reach the 0.15% level, the level at which sensitive plant species such as big sagebrush are affected.

After 16 years, the soil salinity level would approach 0.35% (a moderately saline soil), a level which will affect most of the species currently growing in the area. Using the lowest rates of accumulation projected by the same model but different inputs (5 $g/m^2/yr$ to distances of as much as 450 m (1,476 ft) downwind), the slightly saline effect would not be achieved for 135 years. Thus, by this model, the effects of salt drift are expected to attenuate with distance from the tower with little or no impact beyond 450 m from the tower.

Low rates of salt accumulation in soil will not impact the local halophytic greasewood and shadscale plant communities. Local halophytic plant species include four-wing saltbush, winterfat, gray horsebrush, rubber rabbitbrush, dwarf rabbitbrush, broom snakeweed, eriogonums, milkvetches, chenopods, and several grasses. In contrast, the most severe toxic effects would probably occur among the common broad-leaved shrubs, such as Utah serviceberry, mountain snowberry, big sagebrush, true mountain mahogany, and wax currant, if the salt drift reaches these species (Section 6, Chapter 5).

Although noise will be suppressed by proper mitigation measures, noise associated with Tract C-a operations constitutes a potential impact on wildlife. Noise from the ventilation fans, compressors, conveyors, and

crushers will be continuous. Haul trucks will intermittently add to this level. The Noise Control Plan (Section 6, Chapter 4) outlines the plan to control the noise anticipated during commercial operation.

Adverse effects of high noise levels on humans have been studied extensively. Some effects of noise on laboratory and domestic animals have been documented but, in general, the duration and intensity of exposure was at acute rather than chronic levels. Unfortunately, limited data exist regarding the effects of noise on free-ranging wildlife.

Noise from operations on Tract C-a will consist of steady, residual, and intermittent intrusive sounds. It is unlikely that the predicted noise levels will affect wildlife beyond the tract. Noise levels will vary on tract and particularly near the compressors. Topography and vegetation cover affect sound wave transmission and will moderate noise levels. Potential effects on wildlife include avoidance behavior (e.g., animals moving away from noise sources). Important wildlife species on tract (e.g., mule deer, mourning dove, cottontail) are apparently able to survive and prosper near centers of human activity. These species survive adjacent to highways, airports, and industrial facilities (such as mining sites) when suitable habitat is available.

No adverse impacts are expected from dust produced by the crushers since excessive dust will be controlled.

The use of low BTU gas in power generation produces some gaseous and particulate emissions. A detailed discussion of the potential effects of these impacts on terrestrial vegetation is presented above in "Operational Impacts".

D. Storage and Transfer Impacts

1. Source - Storage of fuel, chemicals, machinery, and explosives will generally be similar to that described for the Modular Development Phase and may result in accidental spills or releases. Small retention

ponds (less than 5 acres) will be used in conjunction with the seepage water treatment plant. A catchment basin will be built north of the processed shale disposal pile to collect leachate and runoff from the pile. Surface soil will be stockpiled adjacent to the disposal area until it is needed for revegetation. Enclosed conveyor belts will transfer crushed shale ore (36,000 tons/day) to the surface retort feedstock near the processing complex; conveyors will also be used to transfer processed shale to Rinky Dink Gulch for disposal.

2. Mitigation Measures - Facilities used to store toxic chemicals will be diked to prevent contamination should a spill occur. If spills occur they will be cleaned up immediately to prevent any discharges (Section 6, Chapter 7). Retention ponds and the processed shale catchment basin will be lined to prevent contamination of surface or groundwater sources. Feedstock piles will be diked to prevent leachate discharge. Surface soil stockpiles will be seeded with quick-growing annuals to prevent dust problems. The conveyor belt will be elevated 10 feet or more above the ground in several locations to prevent disruption of deer movements.

3. Impact Assessment - Storage areas will be primarily confined to the compressor area and the processing complex on Airplane Ridge. Since discharges and spills will be mitigated, no impacts are expected to result from storage facility locations. Dikes surrounding the crushed shale ore feedstocks will prevent discharges of leachate and therefore adjacent vegetation should not be affected. The quality of the water in the ponds or catchment basin cannot be determined at this time. If high concentrations of substances that can adversely affect wildlife occur, RBOSP will take appropriate measures to restrict wildlife use of the water.

Storage of surface soils should not adversely affect surrounding vegetation. Temporary reseeding of the area will prevent excessive dust. Reseeding the stockpile with a quick-growing annual such as barley might enhance food availability for seed-eating mammals and cottontails. Recent

experience with the revegetation experimental plots indicates that lagomorphs use barley.

The enclosure of conveyor belts should prevent dust contamination of adjacent soils and vegetation. Discharges from the processed shale pile will be contained, thereby preventing the discharge of trace metals.

E. Disposal Impacts

1. Source - By-products of underground retorts will include MIS retort water and low BTU gas. The MIS retort water will be used in surface retorting and mine seepage water will be treated and reinjected. The low BTU gas will be treated and used in the gas turbine generators to produce most of the power required for mining and processing operations on the tract. Surface retorting will require disposal of processed shale onto 880 acres of Rinky Dink Gulch. Sewage will be treated at the sewage treatment plant and the resultant sludge will be disposed of with the processed shale.

2. Mitigation Measures - Planned methods for disposal of MIS retort water, mine seepage water, and sewage should not cause environmental problems, and therefore mitigation activities are not planned. Treatment and combustion of low BTU gas will produce gaseous and particulate emissions which will be scrubbed to meet Federal and State standards. The processed shale pile will be periodically watered to reduce dust and facilitiate compaction and stabilization of the processed shale. Leachate and runoff from the processed shale will be collected in an evaporation pond at the base of the gulch. A dam will be constructed at the head of the disposal pile to prevent washouts. Standing water above the dam may be present for short periods after a severe storm, but due to the low frequency of such storms, this is not expected to have long-term effects. (See Section 6, Chapter 6). An artificial soil profile will be constructed on the processed shale disposal pile and will be revegetated (Section 6, Chapter 8.4). The artificial soil profile will reduce the possibility of introducing toxic elements into the terrestrial system and will

enhance the physical and chemical conditions for plant germination and growth.

3. Impact Assessment - Disposal of product water, mine seepage water and sewage should not adversely affect biota. Disposal of sewage sludge could provide organic matter to the reestablished vegetation if incorporated into the surface soils applied to the raw shale ore. Selection of a disposal site for the processed shale was limited to the 5100 acre tract since RBOSP has no lease properties adjacent to Tract C-a. Rinky Dink Gulch was selected as the disposal site because this gulch has the least surface flow of the four gulches occurring on tract and is compatible with engineering design plans for stabilization and water quality control. The habitats to be disturbed by disposal (Table 7-4-1) are primarily upland sagebrush and pinyon-juniper associations. The potential for erosion in these areas is slight in the bottomlands, moderate on the north facing slopes, and severe on the south facing slopes (RBOSP Progress Report 10, 1977). Relative to the rest of the tract, the area to be modified provides moderate quality habitat for mule deer and other fauna. Mule deer apparently use Tract C-a in the spring but are uncommon in other seasons. Herbaceous cover is sparse (sagebrush = 15%; pinyon-juniper = 6%) in the area but the browse conditions are good (RBOSP Progress Report 10, 1977). Feral horses are common on Wolf Ridge throughout the year. They were also frequently observed on Dead Horse Ridge, along Stakes Springs Draw, and in Section 19 southwest of the tract (RBOSP Progress Report 10, 1977). The use of Rinky Dink Gulch and adjacent Wolf Ridge as a disposal site should not adversely affect the feral horse populations on and near Tract C-a. Increased competition for food among horses and between cattle and horses should not be critical since habitat modification programs (Section 6, Chapter 11) should increase forage availability in areas adjacent to Tract C-a.

Small mammals generally occur in moderate numbers in the sagebrush and pinyon-juniper habitat which occur in Rinky Dink Gulch (RBOSP Progress Report 10, 1977). The least chipmunk, deer mouse, Colorado chipmunk,

and thirteen-lined ground squirrel were the most commonly captured species. The lack of woody overstory in the area makes it a relatively important feeding area for raptors (e.g., red-tailed hawk, American kestrel, and great horned owl).

Because of the gradual process of clearing and vegetation, the disturbance of the 880 acres will not involve a complete loss of habitat at one time. Mule deer will probably alter their travel routes through the area, but the area does not provide critical mule deeer habitat. Small mammal populations should not be greatly altered. Noise and human presence could reduce predation by raptors that are sensitive to this type of disturbance (e.g., Cooper's hawk, sharp-shinned hawk, saw-whet owl, and long-eared owl). Impacts on fauna will be further reduced because the habitat modification program should provide suitable habitat for certain species in adjacent areas while the disposal site is being revegetated.

The establishment of a stable plant community on the processed shale disposal pile should prevent any long-term adverse effects on the existing wildlife. RBOSP has designed an artificial soil profile (Section 6, Chapter 8.4) which is expected to reduce, or possibly eliminate, any adverse toxic effects which might limit revegetation success. In addition, the artificial soil profile should allow the establishment of more diverse forage and browse plant species, which might otherwise be limited to halophytic species, and will therefore provide better conditions for domestic and feral animals.

Revegetation will extend over a 30-year period and therefore portions of potential habitat will be removed from wildlife use for a long period of time.

The combination of the wildlife management plans and the revegetation program during the Commercial Phase should reduce the net impact of processed shale disposal.

F. Manpower Impacts

1. Source - Manpower requirements will peak around 1985 during construction of commercial retorts and continued operations of modular retorts. Estimated manpower projections for this period are approximately 1900 to 2500 workers. Permanent employment will range from 1550 to 2075 workers. The heaviest flow of traffic into the area will be along the planned access route from Rangely. Some workers may use the currently existing access roads from Meeker and Rifle.

2. Mitigation Measures - The impacts of the influx of such a large work force into the relatively small communities near the area, especially Rangely, have been addressed in a cooperative "Rangely Master Plan." RBOSP worked closely with Rangley officials to formulate a plan for the orderly growth of Rangely in the event of oil shale development. RBOSP will work closely with other affected communities to aid them in developing expansion plans. RBOSP has stationed an official in Grand Junction whose sole job is to communicate with local residents and to answer all questions they may have regarding development. In turn, he relays the concerns of local residents to RBOSP Management.

Potential impacts to wildlife in the area by increased human presence are also of concern to RBOSP. To mitigate these impacts, RBOSP will provide its workers and the public with information on the effects of the human presence on wildlife. Potential adverse impacts normally not considered by humans (e.g., disturbance to nesting raptors resulting from nest site investigation), as well as more obvious impacts (i.e., road kills) will be discussed in a brochure. This brochure will be made available to all workers and visitors to the area.

Additional mitigation measures will include posting of speed limits and wildlife crossing signs to alert motorists to the presence of wildlife and, hopefully, to reduce road kills. Offroad vehicle use will be discouraged and possession of firearms by workers during working hours will be prohibited. Litter barrels will be placed throughout the area

and signs prohibiting littering will be posted. In addition, RBOSP will periodically collect refuse left on the tract by humans.

3. Impact Assessment - The combined presence of as many as 3,000 workers is likely to produce some unavoidable adverse impacts on wildlife and vegetation in the area in spite of the mitigation measures taken. Unfortunately, the magnitude of these impacts is difficult to predict. Impacts which cannot be entirely avoided include increased hunting pressures (both legal and illegal) from workers and the public, littering, offroad vehicle use, increased road kills, increased fugitive dust from use of unimproved roads and wanton destruction and harassment of wildlife by thoughtless humans and their pets.

If the impacts from increased human use become excessive, RBOSP will consult with the AOSO and CDOW to plan some means to prevent further damage.

G. Subsidence Impacts

1. Source - Burning of underground retorts will produce voids which may cause a general surface lowering of 5 feet or more across the areas involved. In areas with overburden depths less than 300 ft above the underground retort, surface displacement may be as much as 60 feet. Should such subsidence occur, the event may be rapid, beginning with a funneling through the overburden above the burned out retort, followed by progressive subsidence along the retreating retort face.

2. Mitigation Measures - RBOSP is investigating several alternatives to mitigate and prevent subsidence (Section 8, Chapter 8). These alternatives include backfilling the abandoned retorts with a slurry of processed shale, filling cracks or depressions with rock material, or fencing subsidence areas to prevent injury to man or wildlife.

3. Impact Assessment - Successful implementation of mitigation measures (e.g., slurry backfilling, fencing, and surface filling) should reduce the net impact of subsidence substantially.

H. Environmental Action Impacts

1. Source - Environmental actions to be taken during the Commercial Phase include a terrestrial monitoring program to assess potential impacts on the soils, vegetation, and fauna in relation to shale oil production and to evaluate the success of the mitigation programs; a habitat modification program to mitigate adverse impacts by enhancing forage and browse availability for domestic animals and wildlife; and habitat restoration through successful plant establishment to replace habitat lost to mining, processing, and disposal activities.

2. Mitigation Measures - The environmental actions in themselves are mitigation measures and if these programs are conducted appropriately, no additional mitigation measures will be necessary.

3. Impact Assessment - The monitoring programs should not significantly affect the vegetation and animals which are being monitored.

The habitat modification and restoration programs were designed to have a positive net effect on terrestrial biota. The habitat modification program will provide alternate sources of forage and browse; the revegetation program will restore vegetation to areas disturbed by construction operation or disposal activities. Further discussion of the impacts of habitat enhancement was presented in the assessment of the Modular Development Phase (Chapter 4.1) and an assessment of revegetation was included in the assessment of disposal impacts during the Commercial Phase.

CHAPTER 5

ASSESSMENT AND MITIGATION OF POTENTIAL AQUATIC IMPACTS

A limited variety of aquatic habitats occur on or near Tract C-a. These habitats are essentially natural, except for utilization by livestock in certain areas, and are typical of aquatic habitats of the Piceance Creek basin. In the following discussion, the potential impacts and mitigation procedures associated with RBOSP development are addressed for two development phases: the Modular Development Phase and the Commercial Phase.

5.1 MODULAR DEVELOPMENT PHASE

A. Construction Impacts - The primary source of construction effects on aquatic habitats of Tract C-a and vicinity will be siltation resulting from increased erosion and fugitive dust from the use of unimproved roads and installation of the dewatering pipeline network. Where the dewatering pipeline crosses existing aquatic habitats some increased erosion is expected, particularly during spring runoff. The increase in erosion and siltation will be minimized through the implementation of the Land Rehabilitation and Erosion Control plan (Section 6, Chapter 8).

The temporary increase in silt loads and turbidity resulting from erosion and increased fugitive dust from construction activities may reduce periphyton production because the attached organisms may be buried faster than they can grow. Increased silting will favor new algal taxa which are adapted to a depositing environment, especially the mobile pennate diatoms. Increased siltation and turbidity will also favor benthic macroinvertebrates which are adaptively protected, such as Caenis and Tricorythodes. These changes in the periphyton and benthos communities will be limited to areas on or near the tract, particularly

sampling stations 8, 9, 13 and 14 (Figure 7-5-1). Silt loads and increased turbidity are not likely to affect the White River biota or water quality since there is no continuous flow from Tract C-a through Yellow Creek to the White River.

B. Mining Impacts - The primary effects of mining on aquatic habitats will be a reduction in flow in certain spring brook and pond habitats on Tract C-a due to mine dewatering. Mitigation of dewatering effects will include maintenance of surface waters in some aquatic habitats and reinjection of mine seepage water. The dewatering process will convert some aquatic habitat from a permanent to an intermittent nature so that these areas will contain water only after periods of precipitation or snowmelt.

The reduction in surface water availability will affect the two major biotic communities of the spring brooks and ponds, the periphyton and benthos. During the period of aquatic baseline studies the periphyton communities of these habitats were dominated by Achnanthes minutissima, Navicula pelliculosa, Bioeca lacustris, Navicula cryptocephala, Nitzschia frustulum, and Nitzschia denticula and the benthos communities were dominated by Tubificidae, Chironomidae, and Simuliidae.

There were no major differences between intermittent and permanent area periphyton communities and therefore decreases in flow are not likely to greatly affect periphyton community composition. Although densities of benthic macroinvertebrates were lower in the intermittent stations than in the permanent areas, the benthos of the tract region is also well adapted to the intermittent conditions. Short life cycles and certain resistant stages enable many macroinvertebrates to withstand droughts. However, the length and frequency of the dry periods will determine which of the species will survive. Since there is no evident surface flow connecting Tract C-a with lower Yellow Creek, the fauna of lower Yellow Creek or the White River do not depend upon biotic input from tract area waters. There should thus be little or no effect on downstream areas resulting from changes in benthos and periphyton due to dewatering of the spring brooks or ponds on Tract C-a.

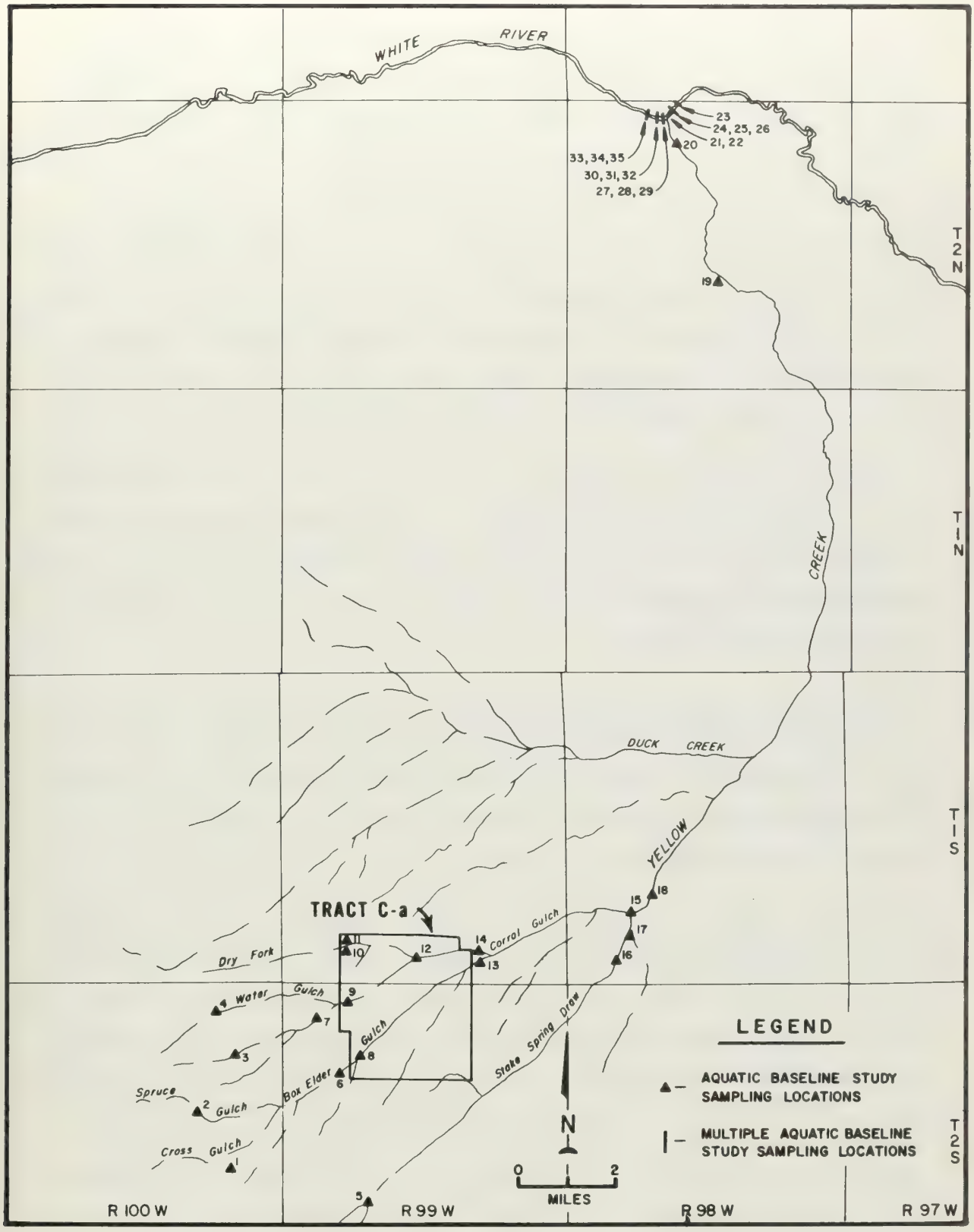

FIGURE 7-5-1

RBOSP AQUATIC SAMPLING LOCATIONS

In the unlikely event of pipeline breakage or of groundwater flow from retorts through zones of fracture, water from dewatering and MIS retort water could possibly reach existing aquatic habitats. The quality of such water will be lower than existing surface water quality and will likely be higher in total dissolved solids, organics, and salts of sodium, calcium, and magnesium. The potential effects of such a discharge would range from no detectable effect to a marked decrease in the abundance of aquatic species. The communities most likely to reflect alterations in the aquatic ecosystem are the periphytic algae and the benthic macroinvertebrates, since the organisms belonging to those communities have limited mobility and are thus more susceptible to transient environmental changes.

C. Processing Impacts - Because the processing facilities will consist of underground modular retorts during this development phase, and because MIS retort water will be incinerated with no discharge to existing surface waters, no impact on aquatic habitats is anticipated during the Modular Development Phase.

D. Storage and Transfer Impacts - Because the storage and transfer facilities will be located at a considerable distance from existing aquatic habitats, and because dikes and retention ponds will be used to prevent discharge to any existing aquatic habitats, no impact on aquatic habitats is anticipated.

E. Disposal Impacts - The sources of impact on aquatic habitats from disposal activities include disposal of MIS retort water and mine seepage water, disposal of solid waste and blasted or crushed rock, and sewage disposal. MIS retort water will be incinerated and excess mine seepage will be treated and reinjected. Because there will be no discharge of either MIS retort water or excess mine seepage water, no effects on existing aquatic habitats are expected. Solid wastes will be removed to approved sanitary land fills and thus their disposal will have no effect on existing aquatic habitats. Runoff from blasted/crushed rock disposal

piles will be collected in retention ponds. Development of sewage treatment facilities will create additional habitat for both periphytic algae and benthic macroinvertebrates on Tract C-a.

5.2 COMMERCIAL PHASE

A. Construction Impacts - During the Commercial Phase, the primary construction effects on aquatic habitats will be increased siltation resulting from erosion and fugitive dust associated with use of unimproved roads and from construction of roads, and disposal and support facilities. The aquatic habitats most likely to be affected by these actions are sampling stations 8, 9, 13, and 14. The increase in erosion/siltation will be minimized through the implementation of the erosion control measures described in the Land Rehabilitation and Erosion Control plan (Section 6, Chapter 8). Fugitive dust will be minimized through procedures discussed in the Air Quality Control plan (Section 6, Chapter 5).

The temporary increase in silt loads and turbidity resulting from erosion and fugitive dust may reduce periphyton production because attached organisms will be buried faster than they can grow. Increased silting will temporarily favor new algal taxa which are adapted to a depositing environment, especially the mobile pennate diatoms. Increased siltation and turbidity will also favor benthic macroinvertebrates which are adaptively protected, such as Caenis and Tricorythodes. These changes in the periphyton and benthos communities will be limited to habitats on or near Tract C-a, particularly sampling stations 8, 9, 13, and 14. Silt loads and increased turbidity are not likely to affect White River water quality or biota since there is no continuous flow from Tract C-a through Yellow Creek to the White River.

B. Mining Impacts - During the Commercial Phase, the primary effect of mining on aquatic habitats will be a reduction in flow in certain spring brook and pond habitats due to dewatering. The exact location of the

affected areas is uncertain, but they will be on or near Tract C-a. Mitigation of dewatering effects will include maintenance of surface waters in some aquatic habitats. The dewatering process will convert some aquatic habitat from permanent to intermittent; the intermittent habitats will contain water only after precipitation or snowmelt. This reduction in surface water availability will affect the two major biotic communities of the spring brooks and ponds, the periphyton and benthos. During the period of baseline studies, the periphyton communities of these habitats were dominated by Achnanthes minutissima, Navicula pelliculosa, Bioeca lacustris, Navicula cryptocephala, and Nitzschia denticula and the benthos communities were dominated by Tubificidae, Chironomidae, and Simuliidae.

There were no major differences between intermittent and permanent area periphyton communities and therefore decreases in flow are not likely to greatly affect the periphyton community composition. Most benthic macroinvertebrates of the tract region are also well adapted to the intermittent conditions. Their short life cycles and certain resistant stages enable them to withstand droughts. However, the duration of the dry periods will determine which of the species will survive. Since there is no evident continuous surface flow connecting Tract C-a with lower Yellow Creek, the aquatic fauna of lower Yellow Creek or the White River do not depend upon biotic input from tract area waters. There should thus be little or no effect on downstream areas resulting from changes in benthos and periphyton due to dewatering of the spring brooks or ponds on Tract C-a.

In the unlikely event of pipeline breakage or of groundwater flow from retorts through zones of fracture, water from dewatering and MIS retort water could possibly reach existing aquatic habitats. The quality of such water will be lower than existing surface water quality and will likely be higher in total dissolved solids, organics, and salts of sodium, calcium, and magnesium. The potential effects of such a discharge would range from no detectable effect to a marked decrease in the abundance of aquatic species. The communities most likely to reflect

alterations in the aquatic ecosystem are the periphytic algae and the benthic macroinvertebrates, since the organisms belonging to those communities have limited mobility and are thus more susceptible to transient environmental changes.

C. Processing Impacts - During the Commercial Phase the surface retorts will be located at a considerable distance from existing aquatic habitats and the product water from both the underground and surface retorts will be used to moisturize processed shale or in the process. There will be no discharge to existing surface waters. Thus, no adverse impacts on existing aquatic habitats are anticipated from processing operations.

D. Power Generation Impacts - Because power generation facilities will be located at some distance from existing aquatic habitats and because there will be no discharge of cooling water to any existing surface water, no impact on existing aquatic habitats is anticipated.

E. Storage and Transfer Impacts - The storage and transfer facilities will be located at a considerable distance from existing aquatic habitats. Dikes and retention ponds will be used to prevent discharge of runoff to any existing aquatic habitats. Therefore no impact on aquatic habitats is anticipated.

F. Disposal Impacts - The sources of impact on aquatic habitats from disposal activities include disposal of product water and mine seepage water, solid waste, blasted rock and processed shale, and sewage. MIS retort water will be used in the process or used to moisturize processed shale and excess mine seepage will be treated and reinjected. Because there will be no discharge of either product water or excess mine seepage, no effects on existing aquatic habitats are expected. Solid wastes will be placed on the processed shale pile.

The potential effects on existing aquatic habitats of the disposal of processed shale include the flow of contaminated surface runoff into

aquatic habitats and the intrusion of contaminated leachate from the piles. Investigations by Ward, Margheim, and Lof (1971) indicate that runoff (due to rainfall) from processed oil shale is likely to contain high concentrations of Na^{+}, Ca^{++}, Mg^{++}, and $SO_4^{=}$, but that concentrations of Ba^{++}, Cu^{++}, Cr^{+6}, F^{-}, Fe^{+++}, Pb^{++}, and Zn^{++} would be less than those allowable for human drinking water. Ward and Reinecke (1972) reported that the dissolved solids concentration in snowmelt water is increased significantly by contact with oil shale residue, but that concentrations are increased more in runoff from rainfall.

The aquatic habitats most likely affected by inflow of contaminated runoff or leachate would be those east of the tract in Corral Gulch (approximately 70 m^2 of aquatic habitat), Yellow Creek (intermittent), and the White River. Because the surface of processed shale will be compacted to form an essentially impermeable surface layer and the runoff from this surface will be diverted via lined ditches to lined holding ponds, there will be no direct discharge to aquatic habitats. In the unlikely event of an accidental discharge due to a dam failure or pond lining failure, the potential effects of such a discharge would depend upon the chemical composition of the discharge and the amount of dilution by the receiving water. The potential effects of the discharge of a highly saline leachate or runoff would range from no detectable effect to a marked decrease in the number of aquatic species and their abundance. The communities most likely to reflect changes in the aquatic ecosystem are the periphytic algae and the benthic macroinvertebrates, since the organisms belonging to these communities have limited mobility and are thus more susceptible to transient environmental changes.

The development of sewage treatment facilities will create additional habitat for both periphytic algae and benthic macroinvertebrates on Tract C-a.

G. Subsidence Impacts - The primary effects of subsidence on aquatic habitats would be localized disruption of existing flow regimes, alteration or elimination of certain spring brook habitats, and, possibly, creation of additional pond habitat.

H. Environmental Action Impacts - The sources of impacts on aquatic habitats from environmental monitoring include temporary reductions in the abundance of periphytic algae and benthic macroinvertebrates in those habitats where sampling occurs. Maintenance of aquatic habitats by water replacement for disturbed surface waters, and creation of additional aquatic habitats through development of retention ponds are some mitigative procedures which will be implemented. The loss of aquatic organisms through sampling will be temporary, as the replacement time for periphytic algae is measured in weeks and that for macroinvertebrates ranges from weeks to a few months.

I. Manpower Impacts - The primary source of impacts on aquatic habitats will be increased siltation and turbidity due to increased use of unimproved roads. Erosion and siltation will be minimized through the implementation of the erosion control measures described in the Land Rehabilitation and Erosion Control plan (Section 6, Chapter 8). The effects of increased erosion and siltation may temporarily reduce periphyton production and will favor macroinvertebrates which are adapted to a depositing environment.

CHAPTER 6

ASSESSMENT AND MITIGATION OF HYDROLOGY IMPACTS

The engineering and the design of the Tract C-a development is based on the API zero-discharge of water concept that is used in these processes. Based on this principal, the environmental effects on the water quality resulting from discharges are eliminated or kept to a minimum. The remaining environmental impacts on the hydrology are confined to dewatering, mining, and abandonment of the burned-out retorts.

6.1 MODULAR DEVELOPMENT PHASE

A. Sources of Impact - The matrix analysis which is introduced in Chapter 1 of this section was used to help analyze the various anticipated impacts on the hydrologic environment from the modular development. The actions during development judged to be potentially important to the hydrological system includes construction of underground retorts, dewatering, reinjection, disposal of product and mine seepage water, and subsidence. The other actions were considered to have either a minimal or immeasurable impact on the hydrologic environment.

1. Mining - In order to mine the oil shale within Tract C-a, the mine must be dewatered. The impacts of this dewatering are a function of the location, length of time and the rate of dewatering. In order to determine these impacts and the rate and time of dewatering, RBOSP developed a computer model of the Piceance Creek basin. This model has been used to simulate dewatering requirements and effects for various mining plans. The model has also been used to simulate reinjection of dewatering water and the effects.

Underground retort construction including shafts and tunnels in some cases will physically occupy the present space of the existing upper

aquifer. The area of course will need to be dewatered prior to this construction so therefore, the mining impacts are related to the underground operations requiring dewatering and reinjection.

Dewatering of the upper aquifer will be required during the Modular Development Phase. The dewatering of the lower aquifer during this phase will be of very short duration during the construction of the production shaft. After the construction of the shaft it is anticipated that no dewatering of the lower aquifer will be required for the first five retorts. Dewatering of the lower aquifer will be required for retorts 6 and up in the Modular Development Phase.

2. Processing - After rubblization the shale is retorted in place by a moving fire front. Because this processing occurs underground in an area previously dewatered, the impact on the hydrologic environment will be insignificant.

3. MIS Retorted Shale - During the Modular Development Phase the processed shale will be essentially in place in the form of burned-out retorts underground. Subsidence and the abandonment of the mine and underground retorts are impacts discussed in Section 6, Chapters 13 and 14, respectively.

4. Support Facilities - Section 6, Chapter 6, discusses the water quality control and the zero-discharge water handling procedures proposed for the Modular Development Phase. The only environmental impact to the hydrologic system from support facilities would be the result of a failure of the zero-discharge system, and this is considered highly unlikely. The spill contingency plans are discussed in Section 6, Chapter 7.

B. Mitigation - The effects of mine dewatering can be substantially reduced by reinjecting the water into the aquifer from which it came. It is anticipated that the reinjection wells will be at a distance of 3-1/2 to 5 miles from the tract boundaries. The exact location of these wells has not yet been determined. Studies are currently underway using

the RBOSP Piceance Creek basin hydrologic model to determined the location, the rate, and the time of reinjection, such that near steady state ground water discharges can be maintained along Piceance Creek and its tributaries.

It is anticipated that the groundater discharge to Yellow Creek may be impacted. The model studies will further define the projected impacts on Yellow Creek. There are several possibilities for the augmentation of mitigation of the groundwater discharge. Some of these methods are:

- Water replacement by means of a water delivery system from RBOSP surface water rights.
- Dedication of water from existing water rights to the stream.
- Release of groundwater to the streams.

Upon completion of the project and cessation of the dewatering reinjection program, mitigation will be required to keep the cone of depression from spreading outside of the area covered by the reinjection wells. The most expedient means of mitigating this impact would be to recharge or backfill the dewatered zone with water from an outside source.

As a result of the dewatering of the upper and lower deep oil shale aquifers during the Modular Development Phase, some springs and seeps may be affected. The mitigation of these affected flows would be by the same methods as those outlined for groundwater discharge to Yellow Creek.

C. Impacts - The data from the 2-year baseline study indicate that the springs feeding the perennial reaches of on-tract Box Elder and Corral Gulches derive their water source from the upper oil shale aquifer. Therefore, at some time after dewatering begins it is anticipated that during most of the year, Box Elder Gulch and Corral Gulch will not support surface flows. However, during spring snowmelt runoff there may be continuous flows as there have been in the past.

Yellow Creek, along its lower reach, i.e. the last few miles before reaching the White River, is anticipated to have a change in surface water flows due to the dewatering and reinjection. The exact nature of these changes is not known at this time. Computer runs on the RBOSP hydrologic model are anticipated to be completed by mid-June 1977. At that time, the projected impacts of the MIS operation should be better known.

The springs and seeps within the area affected by the reinjection wells and the springs and seeps immediately to the west of Tract C-a, which are connected to the upper and/or lower deep oil shale aquifers, will also experience reduced groundwater flows. The exact nature of this reduction will depend upon the hydrologic connection to the source aquifer and its degree of impact. The location of springs and seeps most likely to be affected are shown on Figure 7-6-1. The dewatering studies completed to date indicated that these possible effects would begin after 2 years of dewatering.

6.2 COMMERCIAL DEVELOPMENT

The source of hydrologic impacts, mitigation procedures, and the impacts remaining after mitigation will be the same as those resulting from the Modular Development Phase, with the exception that dewatering of the lower aquifer will be required throughout the 30-year mining period, and the length of time over which the effects will occur will be much longer.

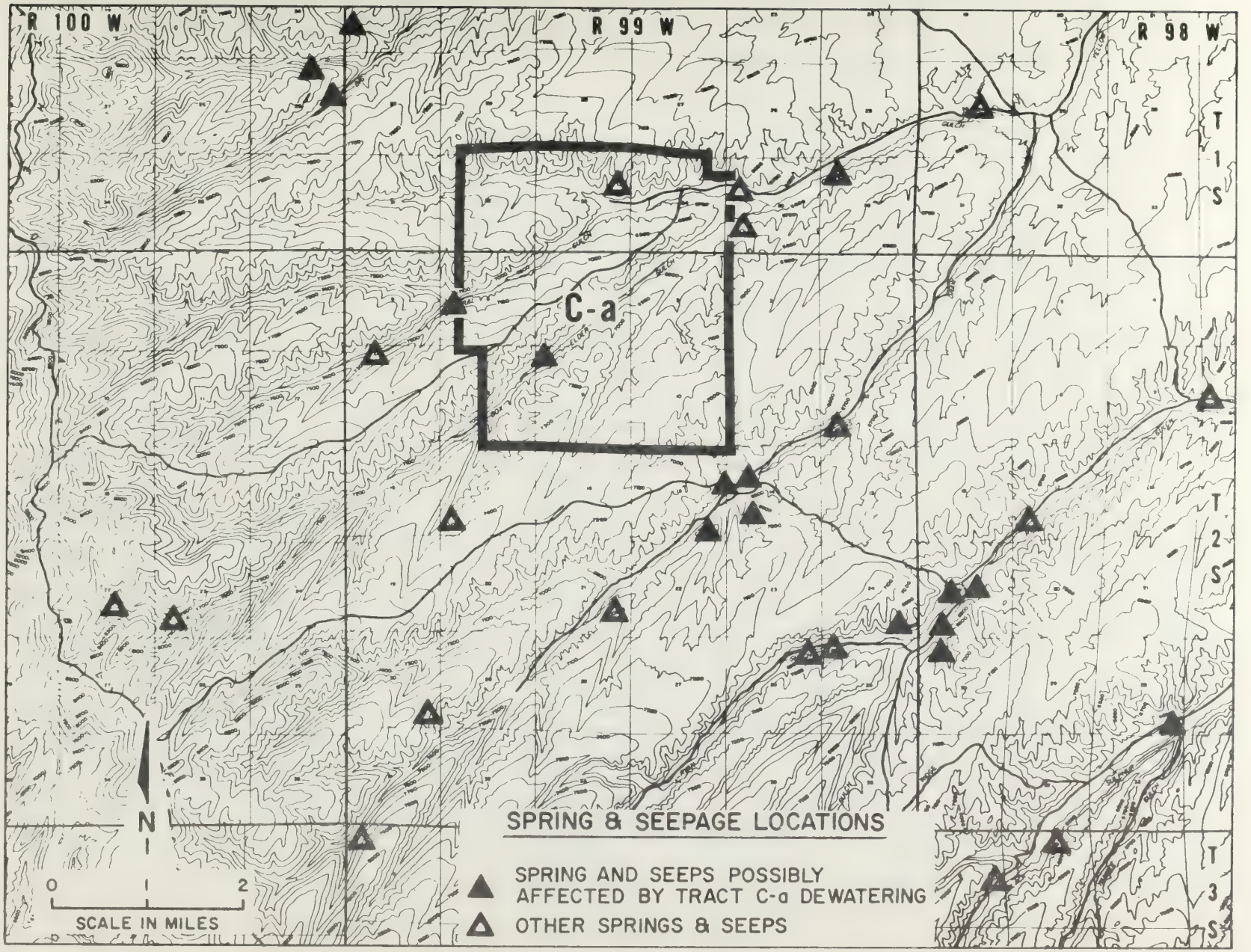

Figure 7-6-1

MAP OF SPRINGS AND SEEPS POSSIBLY AFFECTED BY TRACT C-a DEWATERING

CHAPTER 7
ASSESSMENT AND MITIGATION OF IMPACTS ON CULTURAL RESOURCES

Development activities such as clearing, grading, road and pipeline construction, which result in disturbance to the surface, have the potential to adversely impact cultural resources within the area of disturbance. Adverse impacts result from loss of surface and subsurface artifacts through physical destruction or burial, physical removal of structures or remains, or the disruption of natural features which represent a cultural period or type of activity. Total surface disturbance for the Tract C-a development plan may equal 1,800 acres. Mitigation of these adverse impacts can be accomplished by:

- Recovering surface and subsurface artifacts prior to disturbance and providing for their preservation and documentation.
- Documentation of structures and/or cultural features in place by photographs, drawings, verbal descriptions and maps prior to disturbance.
- Avoiding the area.

Additional impacts can result from increased human activity and the associated unauthorized collection of artifacts.

Administration of cultural resources on public land is subject to a number of State and Federal regulations (see Section 6, Chapter 12). Requirements of these laws are explicit. It is the express policy of Federal and State agencies to preserve, protect and recover antiquities. Requisite to this policy is the requirement to inventory and evaluate cultural resources on lands under public jurisdiction. The inventory requirement was satisfied for the study area by the completion of a 100% cultural resource survey and subsequent publication of a report depicting and describing all cultural resources in the vicinity of Tract C-a (RBOSP, 1976).

Evaluation of these resources was completed by the BLM, and reported as the "Determination of Significance" in an Executive Order 106/2b "Determination of Effect" statement according to guidelines set forth in Executive Order 11593 and the Archaeological and Historic Preservation Act of 1974. According to this document, only two locations in the study area (Site 5RB13 which lies in the vicinity of Cluster I and Site Cluster II) (Figure 7-7-1) are considered worthy of nomination to the National Register of Historic Places. In accordance with regulations, the Bureau of Land Management has provided appropriate mitigation measures for these cultural resource finds as defined in the determination of effect for open pit mining methods (January, 1977). With the revision of the DDP to reflect MIS mining methods, RBOSP has requested the revision of the statement to match these plans. The mitigation measures provided for in the original statement required protection of 5RB13 in Cluster I and Primary sites in Cluster II by avoidance where possible, but when disturbance becomes eminent:

- Primary sites in Cluster II must be flagged, tested, and salvaged by a qualified archaeologist. All recovered artifacts will be mapped, recorded and properly curated.
- Site 5RB13 (within Cluster I) will be tested, and if deemed necessary, excavated by a qualified archaeologist. Salvaged materials must be mapped, recorded, photographed and properly stored.

In addition, the BLM required that, if additional antiquities be discovered during operations, RBOSP immediately notify the AOSS and suspend activities in the area of the discovery until authorized to proceed by the AOSS.

Compliance with the above requirements for protection was determined by the BLM as adequate to provide for "No Adverse Effect" to the cultural resources of the area due to oil shale development.

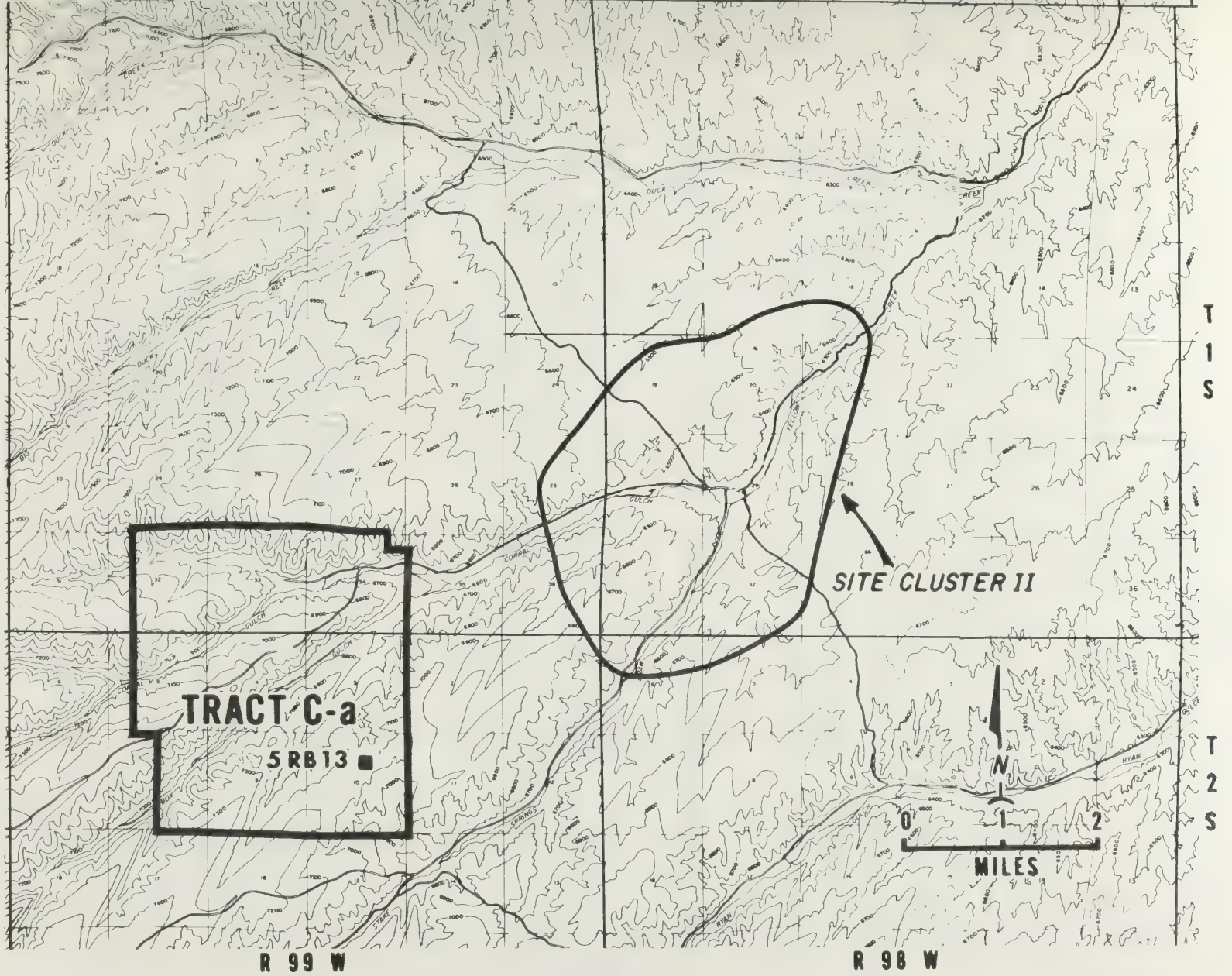

Figure 7-7-1

LOCATION OF ARCHAEOLOGIC SITES NOMINATED TO NATIONAL REGISTER OF HISTORIC PLACES

No additional mitigation measures were specified as necessary for those archaeological, historical and/or paleontological sites which had already been inventoried, mapped, documented/collected from the study area, but which were not nominated to the National Register.

The "Determination of No Adverse Effect" originally released by the BLM was prepared in response to "Open Pit" mining methods proposed by RBOSP in their DDP of March 1976. Since then, RBOSP has proposed an alternate method of development, the Modified In Situ (MIS) process. Disturbance caused by Tract C-a development will result in much less surface disturbance than the originally proposed open pit method. The Bureau of Land Management is currently revising the 106/2b statement in light of new Tract C-a mining plans. Clarification of potential impacts during Modular and Commercial Phases of Tract C-a development follows:

7.1 MODULAR DEVELOPMENT PHASE

Modular Development Phase activities will result in the surface disturbance of approximately 100-200 acres from the period 1977 through 1982. This disturbance will be concentrated in the north-central portion of the tract (Figure 7-1-2) and will largely result from the clearing of surface areas for construction of mining facilities, roads and ancillary facilities.

This disturbance will be limited almost entirely to on tract areas which have already been inspected for and cleared of all cultural resources. The only possible disturbance expected in important cultural resource areas will be the construction of dewatering-reinjection wells off tract. However, prior to the construction of each reinjection well and associated pipeline network, a Special Land Use Permit (SLUP) application will be obtained from the BLM. Stipulations of these land use permits require prior biological and archaeological clearance. Therefore, each reinjection location will be inspected prior to drilling activities to determine if the area has already been cleared. If not, a

qualified archaeologist will be employed to conduct a 100% survey of the site prior to drilling. All antiquities recovered from these sites will be inventoried and evaluated in respect to their significance to the National Register of Historic Places. Should the area be deemed potentially significant, activities in the area will be suspended until the AOSS advises RBOSP to resume activities.

In addition, RBOSP supervisory personnel will be provided with detailed locations of primary sites within Site Cluster II. When development activities of any nature threaten to intrude on these sites, RBOSP will flag them and engage a qualified archaeologist to test the threatened site for evidence of additional material. The AOSS will be kept apprised at all times of the actions involving such sites, and development will proceed only after the AOSS has issued permission to proceed.

Employees will be prohibited from collecting or hunting artifacts as per law and will be asked to report all finds to RBOSP management.

The combination of mitigation procedures just described is expected to provide ample protection for cultural resources in the study area. Therefore the projected negative impacts of modular oil shale development on cultural resources are expected to be zero.

7.2 COMMERCIAL PHASE

Commercial Phase activities may ultimately result in the surface disturbance of 1200-1600 acres. As commercial development proceeds, 5RB13, in the southeast corner of Tract C-a, may be threatened by disturbance caused by preparation of the processed shale disposal pile (Figure 7-1-3). This disturbance may be anticipated around 1986 to 1992. When disturbance of 5RB13 becomes eminent, RBOSP will follow the following procedures:

- A qualified archaeologist will be employed to test the area and to determine the need for further study.
- The AOSS will be apprised of these actions.
- If necessary, based on the archaeologists' evaluation, RBOSP will fund excavation of 5RB13 in the attempt to determine and document the archaeological significance of the area.
- Disturbance of the area will be deferred until testing and/or excavation is complete and the AOSS has granted permission to proceed.

As development proceeds, any previously unreported antiquities discovered will be brought to the attention of the AOSS immediately upon discovery and activities will cease until clearance has been granted and the AOSS has instructed RBOSP to proceed.

Compliance of all of the procedures outlined above are expected to successfully mitigate any adverse impacts of Commercial Phase to cultural resources in the area.

SECTION 7

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LITERATURE CITED

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SECTION 8
ENVIRONMENTAL MONITORING

CHAPTER 1
INTRODUCTION

Development of oil shale on Tract C-a will extend over a number of years during which land will be cleared for roads, mining and processing facilities, disposal areas, and ancillary facilities. TOSCO II processing and gas turbine operation will produce gaseous and particulate effluents. Dewatering will be necessary to prevent flooding of the mine and retorts by seepage from subsurface aquifers and may lead to reduced groundwater flows to surface springs and seeps.

These and other development actions will unavoidably result in impacts or changes in the natural environment. RBOSP will independently implement a variety of mitigation measures to prevent or lessen these impacts (see Section 6 - Environmental Protection Health and Safety). In addition, RBOSP will be actively involved in cooperative efforts with the Bureau of Land Management (BLM) and Colorado Division of Wildlife (CDOW) to implement habitat enhancement procedures.which will provide more productive habitats in areas adjacent to Tract C-a to help offset habitat losses caused by development (see Section 6, Chapter 11).

The proposed oil shale development on Tract C-a is a new type of mining to the semi-arid West; therefore, the full success of planned mitigation measures cannot be guaranteed. To test the success of their mitigation measures, RBOSP will monitor type, severity, and duration of impacts which result from oil shale development. Requisite to this monitoring is the ability to distinguish between natural variation and development-caused perturbation.

A first step in the monitoring plan was to obtain 2 years of baseline data which describe existing conditions. These data were analyzed to identify important or "indicator" species which could be monitored to effectively evaluate the impacts of oil shale development. A description

of the baseline conditions for Tract C-a and the immediate vicinity is presented in the RBOSP Final Environmental Baseline Report (1977).

The second step in the monitoring program was to identify environmental factors that may be impacted. This was accomplished for the Tract C-a development by use of a "cause-effect" matrix (see Section 7, Chapter 1 for a discussion of this matrix). The potential impacts of the Modular Development Phase were assessed with one matrix and the potential impacts of the Commercial Phase were assessed with a second matrix. As explained in Section 7, proposed actions were plotted against environmental factors. Each potential impact was assigned ratings for importance and severity. A scale of 1 to 5 was used to describe rank importance and again to describe severity or magnitude of the expected impact. This matrix was used to identify important impacts. Once the assignment of cause-effect ratings was complete, an interaction matrix was constructed. This matrix provided information on the interaction of abiotic-biotic and biotic-biotic factors.

All ranking couplets of 3/3 or higher were defined as important enough to receive further consideration. Important couplets were analyzed for measurability on yet another matrix (Figure 8-1-1). The purpose of this measurability analysis was to establish whether or not a projected impact could be measured with enough statistical reliability to justify its inclusion in a monitoring plan. Measurability values were ranked from 1 to 5 as follows:

1 - Not measurable with any degree of confidence
2 - Measurable with a small degree of confidence
3 - Measurable with a moderate degree of confidence
4 - Measurable with a high degree of confidence
5 - Measurable with an exceptional degree of confidence

Measurability was based on experience with baseline data analysis and results, expert judgement of specialists in the field and consultation with a biostatistician.

FIGURE 8-1-1
MEASURABILITY MATRIX[1] FOR
SIGNIFICANT (RANK OF 3/3 OR HIGHER ON CAUSE EFFECT MATRIX)
MODULAR DEVELOPMENT PHASE IMPACTS[2]

Source of Impact

Affected Parameters	Underground retort construction	Cumulative construction activities	Dewatering and reinjection	Atmospheric venting	Storage of raw shale ore	Storage of topsoil	Habitat modification	Revegetation
Groundwater								
Quantity	3/3 / 4	3/3 / 4	3/4 / 4					
Quality	3/3 / 5	3/3 / 5	3/4 / 5					
Flow	3/3 / 4	3/3 / 4	3/4 / 4					
Recharge, discharge	3/3 / 4	3/3 / 4	3/4 / 4					
Level	3/3 / 5	3/3 / 5	3/4 / 5					
Availability	3/3 / 4	3/3 / 4	3/4 / 4					
Surface Water								
Quantity	4/3 / 4	4/3 / 4	3/3 / 4					
Quality	4/3 / 5	4/3 / 5	3/3 / 5					
Flow, velocity	4/3 / 4	4/3 / 4	3/3 / 4					
Sediment load	4/3 / 4	4/3 / 4	3/3 / 4					
Temperature	4/3 / 5	4/3 / 5	3/3 / 5					
Springs	4/3 / 4	4/3 / 4	3/3 / 4					
Sediment chemistry	4/3 / 5	4/3 / 5	3/3 / 5					
Soils								
Erosion potential								3/3 / 1
Physical characteristics			3/3 / 3					
Chemical characteristics			3/3 / 3	3/3 / 2	3/3 / 3	3/3 / 1		
Trace metals					3/3 / 3			
Topography								
Slope						3/3 / 3		

FIGURE 8-1-1 (continued)
MEASURABILITY MATRIX[1] FOR
SIGNIFICANT (RANK OF 3/3 OR HIGHER ON CAUSE EFFECT MATRIX)
MODULAR DEVELOPMENT PHASE IMPACTS[2]

Aspect				
		$\frac{3/3}{3}$		
Vegetation				
Productivity	$\frac{3/3}{2}$		$\frac{3/3}{3}$	$\frac{3/3}{3}$
Range condition	$\frac{3/3}{2}$		$\frac{3/3}{3}$	$\frac{3/3}{3}$
Community composition	$\frac{3/3}{2}$		$\frac{3/3}{4}$	$\frac{3/3}{3}$
Distribution	$\frac{3/3}{2}$			$\frac{3/3}{3}$
Cover, density	$\frac{3/3}{2}$		$\frac{3/3}{4}$	$\frac{3/3}{3}$
Browse condition	$\frac{3/3}{1}$		$\frac{3/3}{3}$	$\frac{3/3}{3}$
Small mammals				
Relative abundance			$\frac{3/3}{2}$	$\frac{3/3}{2}$
Distribution			$\frac{3/3}{3}$	$\frac{3/3}{3}$
Species composition			$\frac{3/3}{3}$	$\frac{3/3}{3}$
Large mammals				
Relative abundance	$\frac{3/3}{2}$		$\frac{3/3}{2}$	$\frac{3/3}{2}$
Distribution	$\frac{3/3}{2}$		$\frac{3/3}{2}$	$\frac{3/3}{2}$
Avifauna				
Relative abundance	$\frac{3/3}{2}$		$\frac{3/3}{2}$	$\frac{3/3}{2}$
Distribution			$\frac{3/3}{3}$	$\frac{3/3}{3}$
Species Composition			$\frac{3/3}{3}$	$\frac{3/3}{3}$
Periphyton				
Relative abundance	$\frac{3/3}{3}$			
Species diversity	$\frac{3/3}{3}$			
Habitat	$\frac{3/3}{3}$			
Productivity	$\frac{3/3}{3}$			
Benthos				
Relative abundance	$\frac{3/3}{3}$			
Species diversity	$\frac{3/3}{3}$			
Habitat	$\frac{3/3}{3}$			

[1] Measurability values are defined as follows: 1=Not measurable, 2=Slightly measurable (with statistical confidence), 3=Moderately measurable, 4=Very measurable, 5=Extremely measurable.

[2] Upper values represent importance - magnitude from cause-effect matrix. Lower value represents measurability.

Interactions between abiotic and biotic parameters were identified by use of an interactions Matrix. Over 5,000 potential interactions were investigated. A couplet rating system was used to rank potential interactions between parameters. Values ranged from 1 to 5. The first value represented the importance of the interaction and the possibility of occurrence. The second value represented the magnitude of the interaction in the Tract C-a study area. Magnitude of these interactions was determined through use of RBOSP baseline data. Where appropriate and feasible, statistical analyses were used in evaluating interactions. In many cases value judgements based on qualitative data were made.

Interactions were grouped into four categories:

- Effects of abiotic parameters on abiotic parameters.
- Effects of abiotic parameters on biotic parameters.
- Effects of biotic parameters on abiotic parameters.
- Effects of biotic parameters on biotic parameters.

The range and complexity of interactions on tract preclude a complete discussion herein. However, the matrix illustrating these interactions and a verbal description of their significance are available in their entirety from the AOSS.

The selection of monitoring factors was based on potential for impact, position in the ecosystem network and a measurability of at least 3 (moderately measurable). However, in some cases (e.g., visibility or air quality) exceptions were made and the factor was included in the monitoring plan because of public concern or State or Federal regulations.

The Tract C-a monitoring program is designed to gather statistically reliable data on a limited number of factors. These factors are believed to reflect conditions on Tract C-a. Should future data indicate that this is not the case, the monitoring program will be modified to accomodate new information.

Ambient air quality will be monitored at three sites. Currently existing Sites 1, 2 and 3 (RBOSP Final Environmental Baseline Report, 1977) will be operated. Suspended particulates, sulfur dioxide, nitrogen oxides, methane, non-methane hydrocarbons, carbon monoxide, ozone and hydrogen sulfide will be monitored. Visibility will also be monitored to measure regional air quality.

Meteorological conditions will be monitored at three permanent sites. Baseline data analyses have shown that one site is adequate for extensive meteorological data collection. These measurements will be made at Site 1.

Terrestrial programs will be designed to monitor the adverse and beneficial impacts of oil shale development on plants, animals, and soils in the study area. The chemical composition of soils will be monitored to evaluate impacts of salt drift and gaseous emissions. Vegetation will be monitored to determine the effects of mine dewatering, gaseous emissions, processed shale disposal and subsequent revegetation, and habitat modification on the distribution, cover, and use of vegetation in the area. Fauna will be monitored to assess the impact of habitat disturbance, human presence, noise, and other perturbations on important animal species in the area. Important species are defined as recreationally or economically important, threatened or endangered, critical to the structure and function of the ecosystem, politically important, or important to the survival of one of the above species.

Aquatic programs will be designed to measure those factors which are most likely to be impacted by development and for which statistically valid results can be obtained. Physical measurements will include water temperature, dissolved oxygen, pH, specific conductance, flow velocity, depth, width, turbidity, substrate type, alkalinity, suspended solids, and total dissolved solids. Water quality measurements will include calcium, chloride, boron, fluoride, magnesium, potassium, sodium, sulfate, nitrate, orthophosphate, total phosphate, and silica. Sampling will be conducted for periphyton, benthos, and fish. These parameters were selected on the basis of baseline data analyses.

Development of Tract C-a may drastically affect surface and subsurface hydrology. Analyses of baseline data have shown that sodium, fluoride, silica, pH, and alkalinity can be used to trace the origin and flow of groundwater to surface sources. These constituents will be monitored. In addition, springs and seeps, and alluvial and groundwater aquifers will be monitored periodically and/or automatically to detect changes in level or flow.

Revegetation programs on Tract C-a are vitally important mitigation measures. The monitoring program is designed to determine if self-sustaining and desirable revegetation occurs. Revegetated areas along roads, around buildings, and within corridors will be monitored qualitatively. Revegetation on processed shale and ore disposal piles will be monitored quantitatively by analyses of species composition, percent cover, productivity, and browse condition and utilization.

Subsidence in the vicinity of the burned out retorts will be monitored to determine its rate, extent, and effect on drainage patterns. This information will be used to determine the effectiveness of the mitigative measures used and to prevent injury to workers.

Noise will be monitored in the vicinity of potential noise sources to assure compliance with worker exposure limits. The effects of noise on wildlife will be indirectly determined by the terrestrial monitoring program which will monitor changes in distribution and abundance of large mammals in the area.

CHAPTER 2
AIR QUALITY

2.1 AMBIENT MONITORING

A. Objectives - An ambient air quality monitoring program will be conducted during the Modular Development and Commercial Phases. The objective of a continuing air quality monitoring program is to accurately determine changes in pollutant concentrations as site development proceeds. Compliance with regulations will be established with valid monitoring data. In addition to regulatory requirements, changes in ambient air quality may have a variety of ecological and physical impacts (e.g., changes in vegetation growth rate or reduction of visual range). An accurate historical record of the spatial and temporal variations of air quality on and around the site will permit a quantitative evaluation of ecological and physical changes that may result from chronic or acute exposures to changes in pollutant concentration as site development proceeds.

The development of Tract C-a will result in the emission of a variety of pollutants. The results of the 2-year baseline air quality monitoring program show that before any significant development has occurred, the site area has very low ambient air concentrations of pollutants such as sulfur dioxide, nitrogen oxides, and carbon monoxide that are commonly found in and around urban and industrial centers. The source of these pollutants in urban or industrial centers are the result of energy production through the combustion of fossil fuels. In addition to gaseous pollutants there may be particulate matter introduced into the atmosphere by construction, mining, processing and materials transfer during site operations.

The 2-year baseline data program has acquired a data set containing the hourly average concentration of a spectrum of pollutants, concurrent

meteorological data, and measures of sound levels, visual range, and total suspended particulate levels that existed on and around Tract C-a. Measurements were taken at four geographical locations. The difference in measured average pollutant concentration levels among the four sites or between the data years is small. This shows that the present distribution of background pollutants is uniform throughout the site region. The one exception to the uniformity is the distribution of total suspended particulates when sampling was done in the vicinity of unpaved roads.

The average concentration of most of the pollutants monitored during the baseline data acquisition program was below the reliable threshold of detection of the instrumentation used for the measurement. Annual average concentrations of hydrogen sulfide and sulfur dioxide were less than 5 parts per billion. The same was true for the nitrogen oxides. Non-methane hydrocarbons averaged concentration levels of .05 parts per million; carbon monoxide concentration averaged less than 1 part per million. Only measurements of oxidants (as ozone) and total suspended particulates were well within the sensitivity limit claimed for the measurement method.

During the interim environmental study program conducted during the lease suspension agreement, wet chemical measurements of pollutant concentrations (SO_2, H_2S, NO_2, NO, NO_x) will be completed to establish a carefully controlled benchmark measurement that may be duplicated in the future for comparison. The integrated wet chemical measurements will provide an added degree of precision and sensitivity over continuous monitoring instruments.

B. Parameters to be Monitored - During the Modular Development Phase, there will be fugitive dust, additional vehicular traffic emissions, an oil fired steam boiler with a 100 m stack, a waste gas thermal oxidizer and mine shaft ventilators. The boiler stack will emit sulfur oxides and a small amount of nitrogen oxides into the atmosphere. In addition, there may be a trace of unburned hydrocarbon and ash from the oil fired

boiler. The waste gas incinerator will produce sulfur oxides, nitrogen oxides, and unburned hydrocarbons. Mine shaft ventilation exhaust may contain measureable methane and some light hydrocarbon fractions as well as small amounts of fine particulates. Incomplete combustion will also result in the emission of carbon monoxide.

The Commercial Phase of tract development will bring more retorts into operation over a wider area; result in more extensive mining, crushing and surface transport of shale; involve the installation of a gas fired multi-turbine electric power generating station using treated retort off-gas, and the operation of surface retorts. Emissions from the surface retorts and the power generating facility will be vented through 100 m stacks.

The turbines in the power plant emit nitrogen oxides and some unburned hydrocarbons. The surface retorts will produce additional sulfur oxides and fugitive hydrocarbons. Facilities are proposed to scrub hydrogen sulfide, and organic and other sulfur compounds from MIS retort gases prior to combustion in the gas turbines or venting to the atmosphere so that the emission of these compounds should be quite small.

The Tract C-a long term monitoring program will monitor the following:

- Atmospheric suspended particulates.
- Sulfur dioxide.
- Nitrogen dioxide.
- Oxidants (as ozone).
- Hydrogen sulfide.
- Methane.
- Non-methane hydrocarbons.
- Carbon monoxide.
- Visibility.

The number of Hi-vol suspended particulate sampler locations will be expanded and the samplers will be located at least 3 m above the ground surface.

All of the gaseous pollutants are expected to result from development activities on the site.

Visibility in the tract area has been measured for a 1-year baseline data year. Measurements were made with a photographic photometry method which permitted a quantitative measure of the visual range in a number of directions from an observation site which permitted views of distant objects across the Piceane Creek basin. During the year, the visual range differed from season to season. The air quality monitoring program will duplicate the baseline methodology for acquiring the photometric measurements during the spring season and the fall season of alternate years. During the spring season, visual range is reduced, and during the fall it is the greatest, based on the baseline data year. Changes in basin visibility are not expected to occur rapidly as a result of tract development, and the alternate year evaluation should be adequate to detect trends before they become irreversible.

Instrument technicians who are responsible for the operation of the air quality and meteorological equipment will make qualitative observations of visibility on a weekly basis to maintain a continuity with similar observations made during the baseline period.

C. Monitoring Sites - Monitoring sites have been selected based on dispersion modeling of the impacts of projected operations. This work (Section 6, Chapter 5) showed the general area of maximum impact to be to the west of the tract boundary. No single point of maximum impact can be identified because results differ for different pollutants and for the various time periods addressed in the body of Colorado and Federal ambient air quality standards.

Site 1 has been selected as being representative of the area of maximum impact. Although most of the model results would favor a more south and westerly location, this will allow the use of a major, established site at least through the Modular Development Phase. During the Modular

Development Phase actual operating emission data and air quality-meteorology monitoring data will be examined to determine if relocating this site is justified.

Monitoring Site 2, located south of the southern tract boundary, will be maintained to measure the quality of the air mass as it enters the area of operations. To monitor pollutant concentrations downwind of the tract a compliment of instrumentations will be maintained at Site 3, just east of the eastern tract boundary. The monitoring site locations are shown on Figure 8-2-1. Two additional Hi-vol suspended particulates samplers will be used throughout areas of high vehicular activity to gather data on the effectiveness of dust suppression controls.

The monitoring sites will include a sulfur dioxide detector, a non-methane hydrocarbon detector, and a high volume sampler to measure suspended particulate matter since these are the most likely pollutants to be emitted and can serve as an indicator of diffusion of all pollutants from the operations.

D. Monitoring Frequency - The automatic data acquisition system installed at monitoring Site 1 is capable of collecting continuous data scans, computing and recording the data as hourly average concentrations for each gaseous pollutant. Since most regulatory requirements for ambient air quality concentration limits are based on hourly average concentration or on periods easily computed from hourly average values, hourly averages (clock hour) will be computed and recorded on a continuous basis.

Data will be analyzed statistically at the end of each season (four times a year) and an annual summary which will include the concurrent meteorological data will be prepared.

Suspended particulate samples will be taken every sixth day.

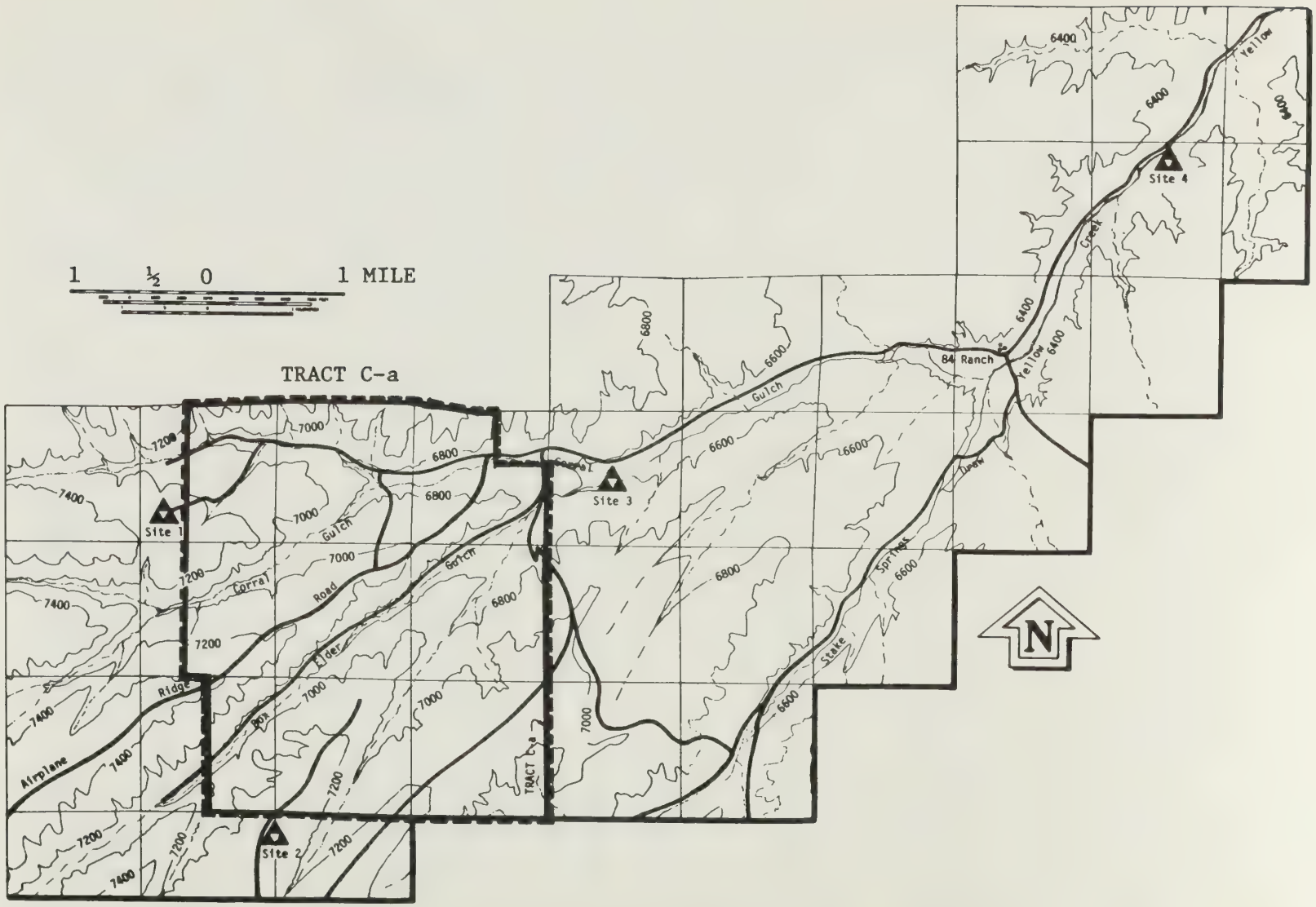

Figure 8-2-1

TOPOGRAPHIC MAP OF AREA AROUND TRACT C-a SHOWING LOCATIONS OF BASELINE METEOROLOGICAL AND AIR QUALITY STATIONS AND RECOMMENDED MONITORING SITE

Air quality monitoring equipment will receive a zero and span check every third day and an independent calibration of the monitoring instrumentation will be conducted quarterly or whenever an instrument is repaired or replaced. The monitoring equipment will be certified at the beginning and the end of each monitoring data reduction period. Adjustments to data (if required) will be made prior to data reduction. A documented quality assurance program will be provided for validating the air quality data.

Calibrations will be performed with equipment that itself has been calibrated traceable to the National Bureau of Standards. The calibration report will be a part of the quarterly data analysis report.

2.2 SOURCE EMISSION MONITORING

Permits and approvals must be obtained prior to construction and operation under:

- Federal Significant Deterioration of Air Quality Regulations (U.S. Environmental Protection Agency, 1974);
- Colorado Air Quality Control Regulations (Regulation 3) (Colorado Air Pollution Control Commission, 1975).

The development of Tract C-a is a prototype oil shale development project and the specific requirements for source emission monitoring programs are not defined. The procedures for obtaining permits allow the agencies to require stack monitoring and stack sampling to ensure compliance with emission standards. The RBOSP source monitoring program will consider the pollution control devices employed, stability of operation, and the relative significance of each pollutant. Extensive discussions will be held with regulatory agencies as the engineering monitoring design progresses. Source monitoring and stack sampling that is needed to comply with the terms of permits and approvals will be included in the final design. Sampling ports and access facilities will be installed on each source which is controlled by air pollution control devices.

A trace element analysis of the thermal oxidizer flue gas will be made during the Modular Development Phase. Results will be reviewed in conjunction with trace element analyses in the soils program to determine if continued monitoring is justified. The accuracy of the measurements in both the soils and stack programs and the relative levels found will be important considerations in determining if a continuing program is justified on the basis of its scientific utility and cost effectiveness.

CHAPTER 3
METEOROLOGY

3.1 METEOROLOGICAL MONITORING

The diffusion and dispersion of gaseous, aerosol, or fine particulate matter waste products that are discharged to the atmosphere are governed by the spatial and temporal meteorology of the area in which the release occurs. Tract C-a is traversed by a number of steep sided ravines and gulches which effectively channel the near-surface wind flow. Daytime surface winds are often up-valley (to the southwest) because of differential solar heating of the valley walls, while night-time surface winds which are colder, heavier air, generally flows down the valleys toward the northeast. These surface wind flows will strongly influence the diffusion and dispersion of substances released into the ambient air at ground level or within the first tens of meters above the surface. Elevated emissions such as from stacks that will be released into the meteorological regime 100 m or more above the higher elevations on the tract are more influenced by the gradient winds than by the surface wind flow.

The 2-year baseline meteorological data sets from the four monitoring sites operated during that period have been examined in some detail to characterize the spatial and temporal meteorological patterns that exist on the tract. The geographical location of the four monitoring locations are shown on Figure 8-2-1 (Chapter 2). The most highly instrumented monitoring site was Site 1 just west of the tract, Site 2 was located slightly south, Site 3 just east, and Site 4 was located a number of miles to the northeast in the Yellow Creek valley where nighttime drainage winds from the tract were channeled. In general, the differences observed in average data acquired at the different sites are either small or predictable in relation to wind speed, direction and temperature due to differences in altitude or local topography.

By comparison with long term climatic records available for the region in which the tract is located, the baseline data years are anomalous only with respect to total precipitation. During the baseline period rainfall was scattered and sparse, and snowfall and snowpack were particularly light when compared with historical norms.

The following meteorological monitoring program is recommended for the Tract C-a area to acquire necessary and sufficient data for the detailed evaluation of the long-term effects, both ecological and physical, of the dispersion of all materials released to the ambient atmosphere during tract development. The methodology of data acquisition and the pathways through which the effects will be detected are discussed in the following sections.

A. Meteorological Monitoring Sites - Three permanent sites will be equipped to acquire meteorological data. These sites were used during the baseline data acquisition period. The commonalty of site locations will provide continuity with the baseline data set, especially for the statistics of short-term fluctuations of parameters specific to that location. Due to gross differences in the topography surrounding each monitoring location there are sometimes large variances between sites in short-term data (15-minute periods). Certain changes in baseline instrumentation are proposed. Some of the proposals eliminate the acquisition of redundant data, others cover the addition of certain parameters to expand the utility of the meteorological data.

The principal meteorological monitoring site will be located at baseline Site 1, west of the tract boundary (UTM coordinates approximately 710,000 E, 4,421,000 N). The site is equipped with a 60 m instrumented tower and a trailer housing instrument components and recording equipment. The instrumentation at this site can acquire data to adequately evaluate both surface wind flow at the apex of a typical traverse ravine across the site, and at a height above the surface representative of the gradient wind flow across the tract.

Examination of the baseline wind data acquired at the in-valley monitoring sites in comparison with the Site 1 data shows that the sensors on the tower mounted at the 10 m level detect the up and down valley surface wind flows. The difference in data between sites is largely the difference in the time of onset of flow changes. The in-valley locations detect wind changes earlier in the day, and later in the evening. A comparison of Site 1 data acquired with sensors mounted on the tower at the 60 meter level with data acquired at baseline monitoring Site 2, and with upper air studies conducted on the tract, shows that the upper level tower sensors provide a reasonable measure of wind fields not strongly influenced by surface topography and representative of the gradient wind flow. The instrumentation at this site will provide both a wind sigma and a differential temperature measurement. Both of these measurements are measures of atmospheric stability and are used in the evaluation of the dispersion of atmospheric discharges of pollutants. This factor is also required as a basic input parameter for mathematical models used to predict short and long term distribution of pollutants.

The relative humidity sensor will be replaced with a dewpoint sensor and the precipitation gauges will be relocated at the site to obtain a better, unobstructed exposure.

Permanent monitoring stations will be located at baseline Sites 2 and 3. Site 2 is located just off of the southwest corner of the tract. It provides, in conjunction with Site 1, data useful in implementing the short term dispersion model for estimating air quality impacts. Site 3 is located just east of the northeast corner of the tract in the center of the valley formed by the confluence of Dry Fork Gulch and Box Elder Gulch. Site 3 is particularly well suited to monitor drainage surface wind flows from the tract. An analysis of baseline data from Site 3 and Site 4 shows that in large measure, the data sets are redundant after site specific topography effects are removed. The Site 4 facility will be abandoned.

The meteorological data acquired at this site will be used to correlate with concurrent pollutant measurements to validate model predicted values.

B. Identification of Parameters to be Monitored - The meteorological monitoring instrumentation installed at Site 1, the principal monitoring location, will be as follows:

- Wind direction sensors at the 10 and 60 m levels.
- Wind speed sensors at the 10 and 60 m levels.
- Ambient air temperature at the 10 m level.
- Dewpoint at the 10 m level.
- Total precipitation (heated gauge).
- Solar radiation level at 2 m above the ground level.
- Differential vertical temperature gradient 10 m to 60 m.
- Wind sigma meters for both the 10 and 60 m level wind sensors.

The meteorological monitoring at Sites 2 and 3 will include:

- Wind direction sensor at the 10 m level.
- Wind speed sensor at the 10 m level.
- Ambient air temperature at the 10 m level.
- Wind sigma meter for the 10 m wind direction sensor.

Each parameter will be recorded with an automatic data acquisition system. The data system will record 15 minute average values and hourly average values. Each meteorological parameter will be recorded separately on strip-chart recorders. The strip-chart data provides the potential for the acquisition of measured parameter values for time periods less than 15 minutes.

C. Objectives and Rationale - The purpose of the continuous collection of meteorological data is two fold. One, the historical data set will be used in the estimation of the fate of airborne pollutants generated during development and operations on the tract. This information will

be necessary for correlation of ecological and physical changes observed during monitoring in other disciplines, and two, real time data acquisition will be used to control any site activity which, in combination with any meteorological condition, may result in immediate or long term damage to the environment or violation of applicable quality standards.

Tract C-a development will not have a significant impact on regional or even total tract area meteorology. Where structures are built, or the topography changed, there will be minor alterations of surface winds. Where heat or water vapor are released such as from stacks or holding ponds there will be some very local effects that may be measurable. The proposed locations of the monitoring sites place the data acquisition equipment in locations not anticipated to be strongly impacted by specific phases or details of tract development.

D. Meteorological Data Uses - There are a number of potential effects of tract development which may have a relationship with meteorological factors. The concentration of total atmospheric suspended particulate measured on the tract during the baseline monitoring program (ambient background) was quite small, averaging about 10 micrograms per cubic meter of air. If long-term tract operation or development were to alter the ambient suspended particulate background, two factors might be affected; one, the added particulates could serve as additional condensation nuclei which could alter the physical state of water in the atmosphere, and two, the increased particulates would have an effect on the solar radiation intensity at the surface. Both of these effects would have ecological ramifications through the food chain.

E. Meteorological Data Analysis - Meteorological data is generally treated statistically to determine means and extremes of wind speed, temperature, etc., for historical summary records. The data for meteorological conditions measured on Tract C-a will be similarly averaged and analyzed. In addition, a number of other summaries will be made that apply to the dispersion of pollutants. These will include hourly

stability, class distributions, frequency of occurrence tables for stability class versus wind speed and direction, frequency occurrence tables for wind persistance versus time and direction, frequency of occurrence of surface based inversions, etc.

Since meteorological conditions in themselves are not expected to change significantly due to tract development, this meteorological data will be of most value to other monitoring disciplines, (e.g., ambient air quality). A significant part of the data analysis effort of the monitoring program is a data validation program to insure that original data are accurate. Each sensor will be calibrated using standards traceable to the National Bureau of Standards. Accuracy of $\pm 3^{o}$ in five azimuth will be maintained for direction measurements, wind speed will be accurate to ± 0.5 mph, temperature accuracy will be $\pm 0.5^{o}$ F., dewpoint accuracy will be $\pm 0.5^{o}$ F., and differential temperature measurement accuracy will be $\pm 0.18^{o}$ F. Wind sensors will be replaced with recertified units on a quarterly basis and temperature bath verification of temperature measurements using traceable standards will be performed quarterly. Rainfall and precipitation gauges will be verified using accurate volumes of water. The solar radiation sensor cannot be calibrated in the field and will be returned to the manufacturer for recalibration on an annual cycle.

CHAPTER 4
TERRESTRIAL ECOLOGY

Proposed development of Tract C-a will result in disturbances to terrestrial habitat which could adversely affect the distribution and abundance of wildlife in the area. Baseline data collected over the 2-year period have been used to define the importance of various wildlife groups (small mammals, predatory mammals, large mammals, avifauna, invertebrates) to the Tract C-a terrestrial ecosystem. Habitat analysis has also been conducted (vegetative and soils components of the tract ecosystem) to help quantify the relationships between these factors and to help determine their importance to fauna. Results of these analyses were used to select terrestrial monitoring parameters (Table 8-4-1) which are most likely to serve as indicators of perturbation during development. The magnitude and importance of all potential impacts of the proposed mining and processing actions were identified by a cause-effect matrix analysis and used to determine the factors to be monitored.

4.1 ABIOTIC MONITORING

A. Soils

1. Parameter 1 - Trace Metals

a. Objectives and Rationale - Although the projected gaseous and particulate emissions levels are not expected to significantly affect vegetation, source monitoring will be conducted to determine if trace metal emissions occur. Soil samples will be collected concurrently with air quality samples. If source monitoring indicates that toxic or trace element effluents are emitted from the processing and power generation facilities, soil and vegetation samples will be analyzed to detect the magnitude of trace metals or other toxic elements. If significant

Table 8-4-1

SUMMARY OF TERRESTRIAL MONITORING PROGRAM

Sampling Program	Parameter	Sampling Frequency (Years)	Sampling Technique	Sampling Intensity	Data Analyses
VEGETATION	Distribution of vegetation type	Before, 1,2,3, 4,5,...	Aerial photographs	Tract C-a and 5 mile radius	Preparation of vegetation map; ground truthing
	Productivity & Utilization	Before, 1,2,3, 4,5,...	Double Sampling Method (USDA 1970)	10 Transects/sample site	Analysis of Variance (AOV) Multiple Range Test
	Browse Condition & Utilization	Before, 1,2,3, 4,5,...	Cole (1963)	10 Transects/sample site	Analysis of Variance (AOV) Multiple Range Test
SOILS	Conductivity	Before, 1,2,3, 4,5,...	Soil Cores - (0-10 cm)	20 samples/sample site	Analysis of Variance (AOV)
	Trace elements (As, B, Se, etc.)	Before, 1,2,3, 4,5,...	Soil Cores - (0-10 cm)	20 samples/sample site	Analysis of Variance (AOV)
FAUNA	Small Mammals Species Composition Index of Abundance	Before, 1,3,5,	Pit Trapping Live Trapping	5 Groups (2 transects of 10 traps/group)*	Regression analysis; F-test; Analysis of variance (AOV) (Index of Abundance)
	Avifauna Species Composition Map of Territories Density of Breeding Birds	Before, 1,3,5,	Breeding bird mapping technique (Graul 1976; Hall 1974; Tobbins 1970)	12-45 ha (30-105 acres) (depending on size of area) Divided into 1 ha subunits; 8 replicates of subunits*	Regression analysis: Analysis of variances (AOV) (for density only)
	Mule Deer Density Estimates	Before, 1,2,3, 4,5,...	Pellet Group Counts	16.6 km sq (10 mi sq) study area divided into blocks; quarter-sections within blocks include 25 plots*	F-test; Regression Analysis; Analysis of Variance (AOV)
	Feral Horses	Before, 1,2,3, 4,5,...	General Observations	Opportunistic	Report Observations
	Rabbits Index of Abundance	Before, 1,2,3, 4,5,...	Roadside Counts	50 mile road transect*	F-Test, Regression Analysis Analysis of Variance (AOV)

* Sampling intensity will be determined during the first year study.

increases of trace elements occur in the soil or are detected in the vegetation, an expanded vegetation and/or faunal monitoring program will be initiated. The proposed program is designed to collect soil and vegetation samples which can be stored for potential analytical use if source monitoring indicates that trace metals emissions are occurring. Therefore, the program outlined for these studies is conditional.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in trace metal concentrations between the impact and control sites before development; after development.

H_o: There is no significant difference in trace metal concention in the impact site before and after development; in the control site before and after development.

c. Methods - Maximum dispersion concentrations of particulates (potentially containing trace metals) will occur 8 km southwest of Tract C-a. The impact site will be located in an area of projected maximum concentration (Section 6, Chapter 5) and the control site will be located south of tract where minimum concentrations are expected to occur (Figure 8-4-1). Both the control and impact site will be a 1.5 mile x 1.5 mile area.

Twenty random soil samples will be collected before development and annually after development is initiated. Samples will be collected during August from the surface soils (0-10 cm) of each site. Twenty composite samples of sagebrush leaves will be randomly collected concurrently with the soil samples. Samples will be stored; if source monitoring indicates that trace metals are being emitted from the plant site the samples will be analyzed. Should this occur soil and vegetation samples will be analyzed if necessary for Sb, As, B, Cd, F, Hg, Se, Mo, and V.

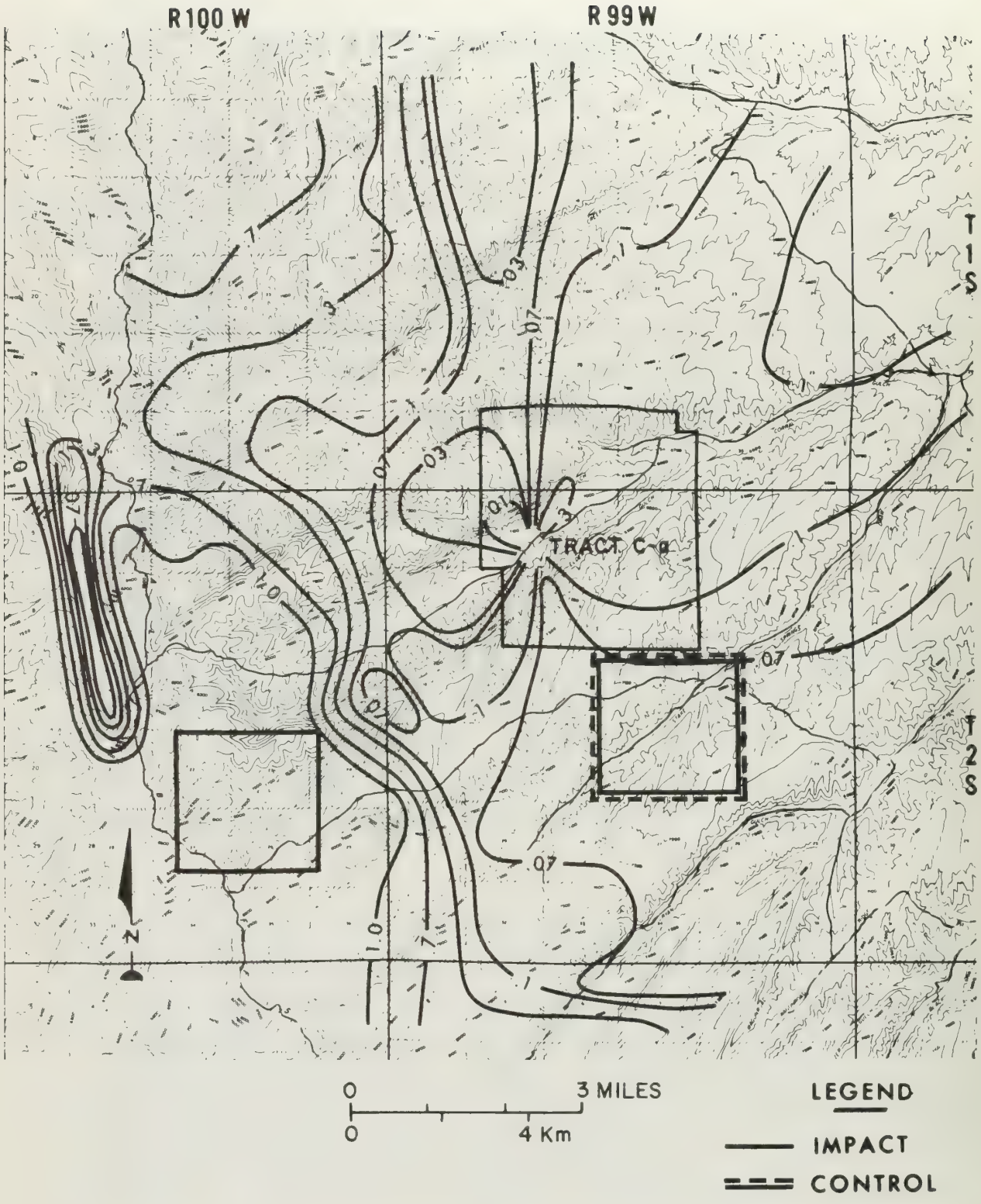

Figure 8-4-1
LOCATION OF SOIL MONITORING SITES BASED ON THE
PARTICULATE DISPERSION PATTERN

d. Experimental Design and Data Analyses - Data collected on the control and impact sites will be analyzed by an analysis of variance (AOV). Data collected before development will be used to test between site differences. After development, a two-way AOV will be used to compare impact effects, time effects, and an impact x time interaction. If the interaction effect is significant, then a multiple range test will be performed to determine the source of the interaction.

2. Parameter 2 - Soil Conductivity Studies for Salt Drift

a. Objectives and Rationale - Projected levels of salt drift dispersion from the cooling towers (Section 6, Chapter 5) are low. The soil studies are designed to detect significant changes in soil salinity or conductivity levels which may be detrimental to plant growth.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in the soil conductivity between the impact and control sites before development; after development.

H_o: There is no significant difference in soil conductivity in the impact site before and after development; in the control site before and after development.

c. Methods - Maximum concentrations of salt drift are expected to occur immediately adjacent to the cooling tower. The impact site, a 0.5 mile x 0.5 mile area, will be located in the area of maximum deposition adjacent to the cooling towers (Figure 8-4-2). The control site (0.5 mile x 0.5 mile) will be located on tract, east of the plant site (Figure 8-4-2). Twenty random samples will be collected annually during August from the surface soils (0-10 cm) of each site. These samples will be analyzed to determine soil conductivity.

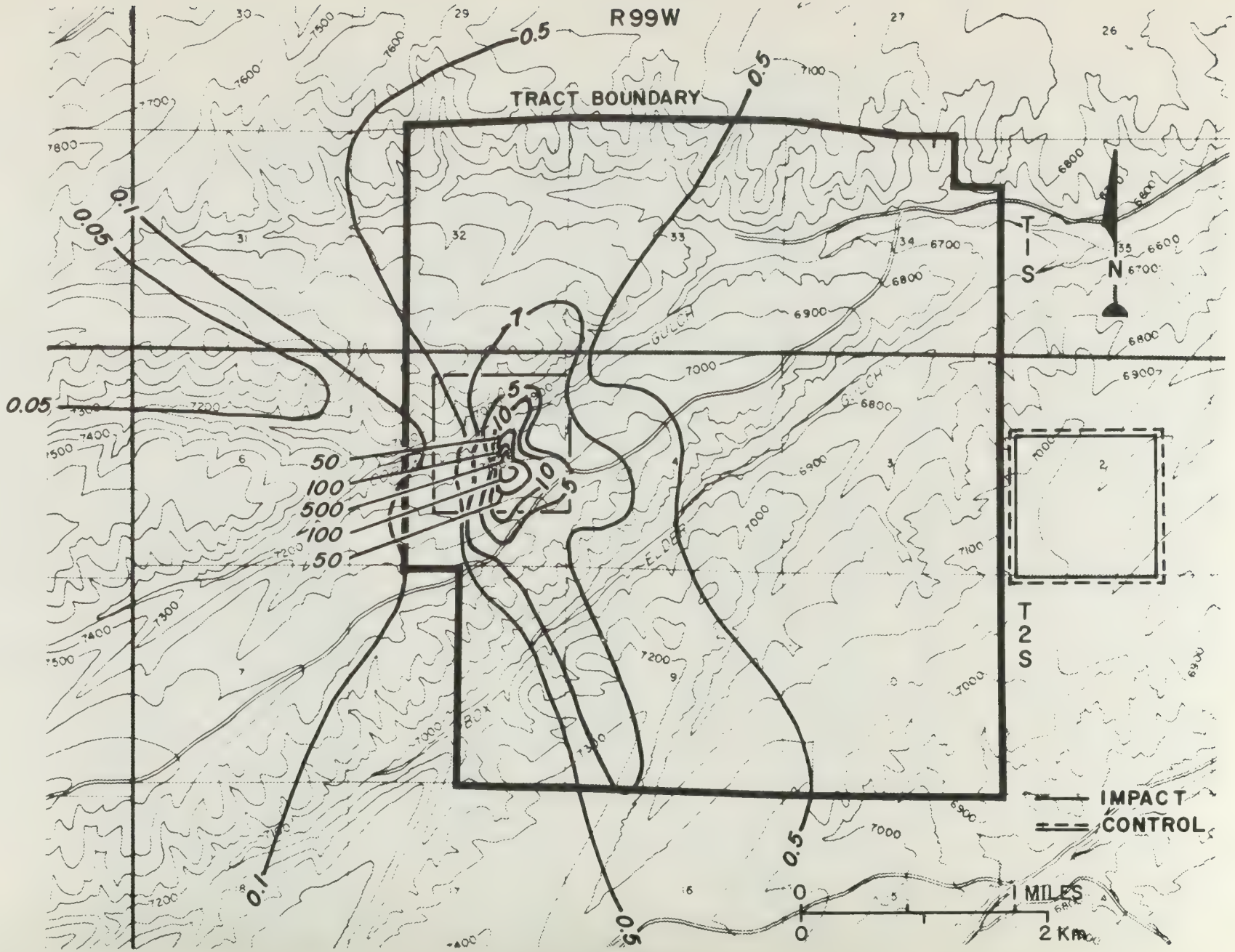

Figure 8-4-2

LOCATION OF SOIL MONITORING SITES BASED ON THE SALT DRIFT DISPERSION PATTERN

d. Experimental Design and Data Analyses - Data collected on the control and impact sites will be analyzed by means of an AOV. Data collected before development will be used to test between site differences. After development, a two-way AOV will compare impact effects, time effects, and an impact x time interaction. If the interaction effect is significant, then a multiple range test will be performed to determine the source of the interaction.

B. Air Quality - Air quality source monitoring will provide the initial prediction of trace metal emission. The air quality monitoring program is discussed in Chapter 2.

C. Meteorology - Climatic data will be used to determine the physical conditions which are important in evaluating other biotic data. The meteorology monitoring program is presented in Chapter 3.

4.2 BIOTIC MONITORING

A. Vegetation

1. Parameter 1 - Vegetation Type Distribution

a. Objectives and Rationale - The Tract C-a development may affect the local distribution of vegetation as a result of construction, dewatering, and particulate emissions. This study is designed to monitor the distribution of vegetation in the tract vicinity to determine changes resulting from Tract C-a development.

b. Hypothesis - No statistical test will be made since this program will provide only qualitative information.

c. Methods - Color infra-red aerial photography (1 inch = 2000 feet scale) will be taken annually, beginning prior to Modular Development Phase construction. The photographed area will include Tract C-a and

the area within a 5-mile radius area. A vegetation map will be drafted from each set of aerial photographs delineating the location and extent of the vegetation types in the study area. The vegetation map will be verified through a qualitative ground survey.

d. Experimental Design and Data Analyses - Acreages of each vegetation type within the study area will be calculated. These acreages will be compared between years to determine any changes in habitat resulting from Tract C-a development.

2. Parameter 2 - Range Productivity and Utilization

a. Objectives and Rationale - Tract C-a development will reduce forage availability and may, therefore, affect animal distribution in the vicinity of Tract C-a. The range productivity studies are designed to provide range use information for areas adjacent to disturbance. Impact areas have been selected on the basis of their importance to fauna prior to development and/or their proximity to mining and processing activities.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in range productivity or range use between the impact and control sites before development; after development.

H_o: There is no significant difference in range productivity or range use in the impact site before and after development; in the control site before and after development.

c. Methods - Control and impact sampling sites will be located in mixed brush, pinyon-juniper, and upland sagebrush (Figure 8-4-3). Impact sites for the three vegetation types are located in the southwest corner of the tract since this area is adjacent to development disturbance and lies in the dispersion area projected for gaseous and

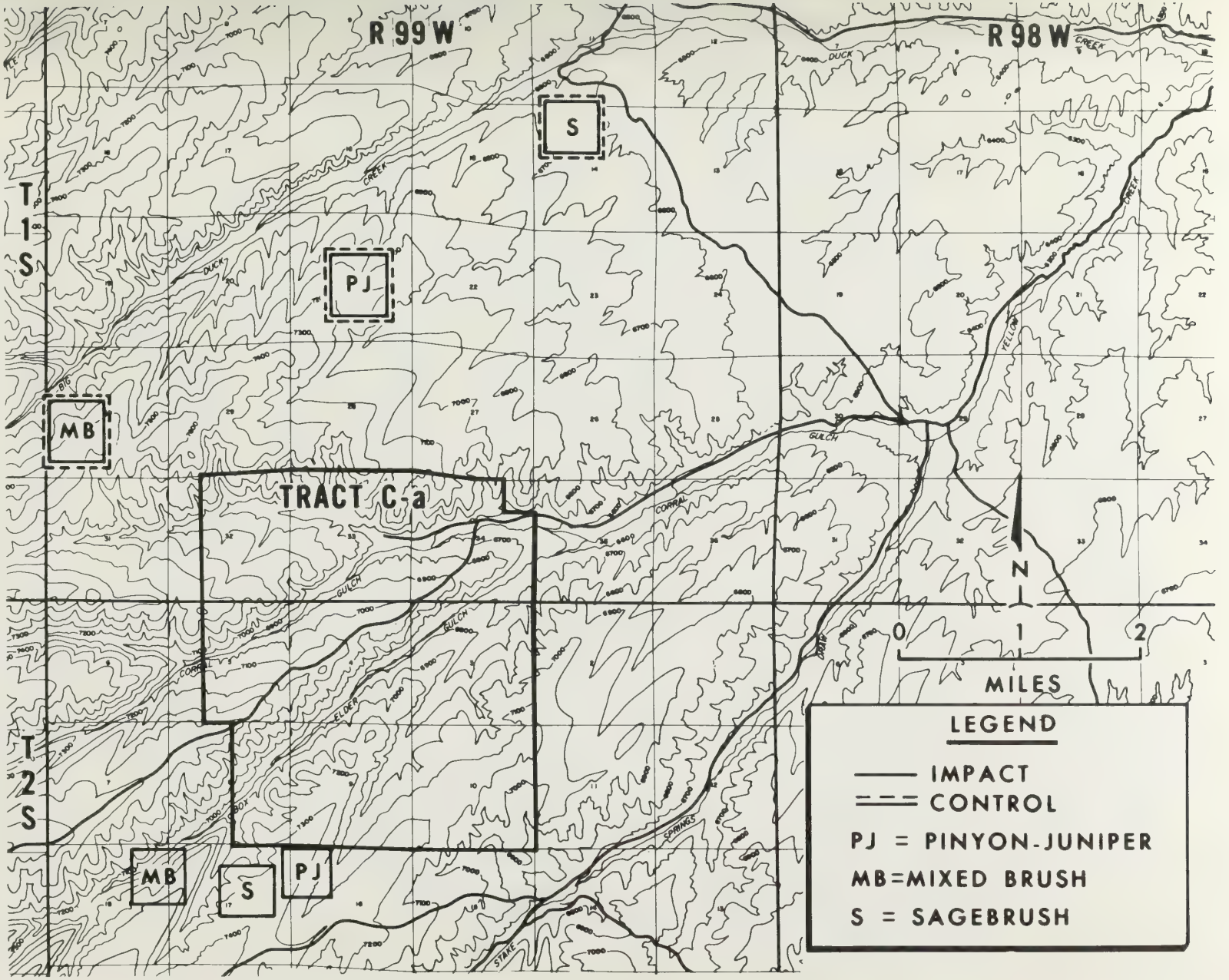

Figure 8-4-3

LOCATION OF THE VEGETATION MONITORING SITES

particulate emissions. Therefore, any cumulative effects might be detected in this general location. Data collected from transects in these vegetation types during the baseline studies have been previously analyzed to determine a coefficient of community (CC) and the percentage similarity (PS) (Pielou, 1974). The results and interpretations of these comparisons are presented in the RBOSP Final Environmental Baseline Report (1977).

An adequate sampling size, based on total herbaceous cover, was determined for each vegetation type. These estimates were calculated for each of the six sampling periods in 1975 and 1976 (RBOSP Final Environmental Baseline Report, 1977). Based on 1.0 x 0.5 m quadrats, an adequate sampling size (accuracy of $\pm$ 10% of the mean 90% of the time) is 302 sample quadrats for mixed brush, 383 for pinyon-juniper, and 403 for sagebrush. The extremely high number of sample quadrats needed for this level of accuracy is not practical or feasible for development monitoring. Sample size requirements to achieve an accuracy of $\pm$ 25% of the mean 90% of the time are 64 for sagebrush, 49 for mixed brush, and 61 for pinyon-juniper. The range productivity and utilization studies will include 10 transects per site (10 plots/transect) or a total of 100 plots. This sampling intensity should achieve a minimum accuracy of $\pm$ 25% of the mean 90% of the time.

Forage will be measured before development and annually after development at the end of the growing season (September). The double sampling method (USDA, Region 2, 1970) will be used. Transects will be selected randomly within the impact and control areas. Two caged plots (9.6 square feet in size), and eight unprotected plots (permanently marked) will be located along each sample transect. Sampling will be done using a 9.6 square foot sampling loop on each of 8 unprotected plots. Production of the dominant grass and forb species (species making up 90% of the individuals) within the loop will be estimated by ocular weight to the nearest gram. Species providing less than one percent biomass will be recorded as present, but will not be weighed. The two protected plots will be clipped, bagged separately, weighed green and recorded. Correction factors will be calculated from the estimated green weights

of the clipped plots. Samples will be air dried and weighed to obtain dry weights.

Potential vegetation damage from insect, frost, or gaseous emissions (SO_2 or NO_x) will be qualitatively assessed. Any damage will be recorded and an estimate of damaged vegetation will be calculated to determine the percent of the sampled vegetation which was affected.

d. Experimental Design and Data Analyses - Data collected on the control and impact sites will be analyzed by an AOV. Data collected before development will be used to test between site differences. After development, a two-way AOV will be used to compare impact effects, time effects, and an impact x time interaction. If the interaction effect is significant, then a multiple range test will be performed to determine the source of the interaction.

3. Parameter 3 - Browse Condition and Utilization

a. Objectives and Rationale - Tract C-a development will reduce browse availability and may, therefore, affect animal distribution in the vicinity of Tract C-a. The browse condition and utilization studies are designed to provide browse use information for areas adjacent to disturbance. Impact areas have been selected on the basis of their importance to fauna prior to development and/or their proximity to mining and processing activities.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in browse utilization between the impact and control sites before development; after development.

H_o: There is no significant difference in browse utilization in the impact site before and after development; in the control site before and after development.

c. Methods - Sampling will be conducted on the impact and control sites. Browse will be measured before development and annually after development. Sampling will be conducted in early May after deer have migrated through the Tract C-a area.

Browse utilization will be estimated along transects (10 transects/site) consisting of 25 individual shrubs (Cole, 1963). Transects will be selected randomly within the impact and control sites. Data collected during the first year will be used to determine the number of transects necessary to achieve an accuracy of $\pm$ 25% of the mean 90% of the time.

Browse species to be sampled include: juniper (Juniperus osteosperma), pinyon (Pinus edulis), antelope bitterbrush (Purshia tridentata), snowberry (Symphoricarpos oreophilus), big sagebrush (Artemisia tridentata), and true mountain mahogany (Cercocarpus montanus).

Form class, age, leader use, hedging and availability will be measured.

Potential vegetation damage from insect, frost, or gaseous emissions (SO_2 or NO_x) will be qualitatively assessed. Any damage will be recorded and an estimate of damaged vegetation will be calculated to determine the percent of the sampled vegetation which was affected.

d. Experimental Design and Data Analyses - Data collected on the control and impact sites will be analyzed by an AOV. Data collected before development will be used to test between site differences. After development, a two-way AOV will be used to compare impact effects, time effects, and an impact x time interaction. If the interaction effect is significant, then a multiple range test will be performed to determine the source of the interaction.

B. Fauna - Fauna will be monitored to assess important species which could be significantly affected by oil shale development. Important faunal species include those that are recreationally or economically valuable, threatened or endangered, critical to the structure and

function of the ecosystem, politically important, or important to the survival of one of the above species.

The monitoring program emphasizes important species that could be affected by oil shale development (as determined by matrix analysis). The greater sandhill crane, whooping crane, and the peregrine falcon, which are important due to their threatened or endangered status, were observed in the vicinity of the tract (RBOSP Final Environmental Baseline Report, 1977). The use of Tract C-a by these species was investigated thoroughly during baseline studies, and will be during interim studies. Results to date indicate that the study area does not provide critical habitat for any of these species. However, the presence of these species warrants continued surveillance. During development, all field crews (construction and operations), and on-site biologists will be instructed to look for and report the presence of any endangered or threatened species in the area. To insure a greater probability of discovery and identification of such species, the field crews will be supplied with photographs, descriptions, and behavioral habits on special status species that might occur in the area. All reported sightings will be investigated immediately by qualified biologists and the AOSS will be notified. Should the sighting be verified, RBOSP will meet with the AOSS and appropriate agencies to discuss a monitoring plan for investigating the status of the species involved.

Predatory mammals, reptiles, and amphibians will not be monitored because their abundance and diversity is low and their value as indicators of oil shale development impacts is questionable. Invertebrate studies have not been included in the program because no important species will be adversely affected by oil shale activities. Each sampling program is designed to collect data which can be used to provide a meaningful assessment of oil shale development impacts on the terrestrial system. These assessments will be based on a comparison of conditions existing before development to those measured at periodic intervals during the Modular Development and Commercial Phases of the project. During the predevelopment sampling period, adequate sample

sizes for the various techniques involved will be determined. If necessary, the sampling design will be modified to reflect the results of the initial studies. Placement of sampling units will be randomized to the extent practicable.

Detailed descriptions of monitoring programs for faunal groups listed in Table 8-4-1 are provided below.

1. Parameter 1 - Small Mammal Abundance

a. Objectives and Rationale - A variety of small mammal species have been found on Tract C-a. Small mammals are important components of the diets of many predators. Small mammals also act as seed dispersal agents and compete with other animals for certain food items. Oil shale development on Tract C-a should have no adverse impacts on regional small mammal populations. Habitat enhancement and revegetation programs proposed by RBOSP will increase the amount of food and cover available for certain species of small mammals.

The objective of small mammal monitoring studies is to evaluate the response of these species to the habitat modification or revegetation programs proposed by RBOSP.

b. Hypothesis

H_0: Small mammal population levels are not significantly changed by habitat modification/revegetation.

c. Methods - Sherman live traps, baited with peanut butter and birdseed, will be used. Five trap groups (2 lines of 10 traps each) per sampling area will be used in the first year study (see subsection d). The total number of trap groups and the number of sampling days required will also be determined during the first year study. Traps will be checked twice a day (morning and evening) so that data for nocturnally and diurnally active species are obtained. Animals captured will be

identified, sexed, aged (adult or immature) and released at the point of capture.

Pit-traps will also be used. Approximately 10 pit-traps will be established in each small mammal sampling area. These traps will be placed in locations where shrews or other small mammals might be captured.

d. Experimental Design and Data Analyses - Small mammal trapping will be conducted on treated and control areas before and after treatment. Control areas will be established in habitat similar to that in areas to be modified. Sampling intensity (numbers of sampling areas and trap groups) sufficient to provide indices of small mammal abundance that are within 20 percent of the mean, 80 percent of the time will be determined during the first year study. Sampling will be conducted during the spring and fall (small mammal populations are typically lowest in spring and highest in fall).

An index of abundance (number captured per 100 trap days) will be calculated from live-trapping data (for each sampling area). Data collected before the Modular Development Phase begins will be compared with that collected in subsequent years. Statistical tests will include F-tests, an analysis of variance, and regression analysis where appropriate (Seber, 1973).

Both live-trapping and pit-trapping data will be used to describe the species composition of small mammals in the areas sampled. These data will not be treated statistically.

2. Parameter 2 - Avifauna

a. Objectives and Rationale - Many species of birds were observed on Tract C-a during baseline studies. Bird groups present in the RBOSP study area include waterfowl, shorebirds, raptors, upland gamebirds and songbirds. Tract C-a development is not likely to have significant adverse effects on any regional avifauna populations. Habitat

enhancement and revegetation programs proposed by RBOSP will increase the amount of food and cover available for certain species of birds. Songbirds, especially those that breed on Tract C-a, are most likely to be affected by habitat modification or revegetation programs.

The objective of avifauna studies during the monitoring program is to evaluate the response of breeding songbirds to habitat modification or revegetation programs proposed by RBOSP.

b. Hypothesis

H_0: Breeding songbird densities are not significantly changed by habitat modification/revegetation.

c. Methods - The breeding bird mapping technique will be used. Each study unit will be divided into one ha subunit (2.47 acres). An observer will search each subunit and record species, location, and breeding activitiy (e.g., territorial defense, singing) of avifauna observed. The location and contents of nests observed will also be noted. Replicate samples of each subunit will be obtained. Sampling intensity (number of subunits and replicates) will be determined during the first year study (see subsection d).

Breeding bird mapping studies will be conducted during the peak songbird breeding period (late May-early June). A map showing territories and nest locations will be prepared for each subunit. Additional information concerning avifauna in the RBOSP study area will be collected, by general observation, during the spring, summer, and winter (gamebirds and raptors will receive special emphasis).

Avifauna study units will be established in areas to be treated and in control areas (control areas will contain habitat similar to that to be treated). Breeding bird mapping (Graul, 1976; Hall, 1964; Robbins, 1970) will be conducted in control and treated areas, before and during development activities. Study units will be 12 or 42 ha (30 or 105 acres) depending on the openness of the habitat type being sampled. The

data from the first year study will be used to determine the number of subunits and replication of counts on subunits required to estimate population densities of breeding birds on the study unit within 20 percent of the mean, 80 percent of the time.

d. Experimental Design and Data Analyses - The numbers of breeding birds found in each subunit will be used to calculate the density of breeding songbirds in each study unit. Statistical comparisons of density estimates for control and treated areas will be performed (regression analysis and an F-test in conjunction with analysis of variance - Seber, 1973; Overton, 1971). Territory size and reproductive effort for each species in each study unit will be assessed qualitatively (from maps and field data). Lists of birds observed during qualitative habitat searches will be prepared.

3. Parameter 3 - Mule Deer Density

a. Objectives and Rationale - Mule deer are the most important game species in Colorado in terms of recreational use and money expended by hunters. The Piceance Basin mule deer herd is one of the largest migratory mule deer herds in North America. Tract C-a is within CDOW's Game Management Unit 22 (Piceance).

Moderate numbers of mule deer occur on Tract C-a during migration periods, particularly spring, and during mild winters; at other times mule deer are relatively uncommon on the tract. Consideration of the possible effects of oil shale development at Tract C-a on mule deer is an integral part of RBOSP's Fish and Wildlife Management Plan.

The objectives of RBOSP's mule deer monitoring program are to obtain an index to mule deer density in a 10 x 10 mile (100 square mile) study area centered on Tract C-a, to compare mule deer density estimates from the study area with those from Game Management Unit 22, and to compare differences in mule deer densities within various portions of the study area.

b. Hypotheses

H_o: Mule deer density estimates for RBOSP's 100 square mile study area are not significantly different from those for Game Management Unit 22 (per unit area).

H_o: Mule deer numbers and distribution within the 100 square mile study area are not significantly different before and during oil shale development activities.

c. Methods - Tract C-a will be in the center of a 10 x 10 mile (100 square miles) study area which will be divided into blocks (approximately one section, 1 square mile, each). Quarter sections (160 acres, 64 ha) will be randomly selected from each block. The total number of quarter sections to be chosen will depend on results of the first year study.

During the first year study, 25 sample plots of 1/1000 ha (ca. 100 square feet) each will be systematically spaced within experimental quarter section sampling units. The boundary of each plot will be determined by placing one end of a 5.8 feet (1.78 m) long chain on the center stake and walking around the stake with the opposite end of the chain pulled taut. Pellet-groups found within the circular plots will be counted; to qualify as a group, 6 or more pellets must be present. Groups on the boundary of a plot will be counted if one-half of the total number of pellets are within the plot. The number of sampling units and plots required will be determined following the pilot study (see subsection d). Sampling plots to be used during monitoring will be marked with a numbered metal stake at their center. Pellet-group counts will be made twice a year, once in the spring and once in the fall, to determine the number of pellet groups deposited in the summer and during the migration and wintering periods. All pellet groups will be removed from the plots prior to initiation of monitoring studies. Actual counting will begin with the following sampling period. Each group will be marked to differentiate groups counted during each season. Sampling

will be started before Modular Development Phase construction begins and will be conducted annually thereafter.

d. Experimental Design and Data Analysis - Tract C-a will be in the center of a 10 x 10 mile (100 square miles) study area which will be divided into blocks (approximately one section, 1 square mile, each). This area will be studied before and during oil shale development activities. Assessments of potential impacts of development require knowledge of deer distribution and abundance before mining or enhancement activities begin.

Data collected during the first year will be used to determine the sample size required to provide mule deer density estimates from pellet group data (within 10 percent of the mean 90 percent of the time). Following the first year study, an appropriate number of quarter section sampling units will be randomly selected within systematically chosen blocks. One pellet group sampling grid will be established in each sampling unit (see subsection c).

Mule deer density estimates will be calculated from pellet-group data. The number of pellet groups per unit area, deer days use, and deer per acre in the study area will be determined as described by Overton, 1971. Pellet group data will be analyzed by two methods (grids as sample units and plots as sample units). A square-root transformation analysis of the data will then be performed on grid or plot data, depending on which of the two has smaller confidence limits (Wood, et al., 1970). These analyses will provide an estimate of the number of deer per square mile in the 100 square mile study area. This estimate will be compared with the CDOW estimate for Game Management Unit 22. If pellet-group data are available from CDOW, density estimates for Unit 22 and the 100 square mile study area will be compared statistically (i.e., regression analysis, analysis of variance) (Seber, 1973).

If data collected from each block are adequate (sufficient number of pellet groups), differences in deer densities between blocks will be

compared using an F-test and an analysis of variance. Significant differences between blocks might indicate that oil shale mining or habitat enhancement are influencing deer distribution.

The feasibility of making statistical comparisons of pellet group data will depend primarily on the number of plots sampled and the frequency and distribution of pellet-groups counted. Specific analysis techniques for these comparisons, except for the 100 square mile study area as a unit, will be determined, if feasible, after completion of the pilot study. CDOW is currently conducting experimental pellet group count studies for mule deer in the Piceance Creek basin. Results of pellet counts, and other CDOW mule deer studies, will be incorporated into RBOSP studies to the extent possible.

4. Parameter 4 - Feral Horse Abundance

a. Objectives and Rationale - Feral horses occur on and in the vicinity of Tract C-a. These horses are protected under Federal law and are under the jurisdiction of the BLM. Feral horses compete with cattle and, to a lesser extent, with mule deer for available forage. The objective of feral horse monitoring studies is to provide qualitative information concerning the status of feral horses in the RBOSP study area.

b. Hypotheses - No statistical hypothesis will be tested (only qualitative data will be collected).

c. Methods - Information on the number of horses occurring in the study area will be obtained from general observations, aerial overflights and State and Federal agencies. The information will be collected and compiled annually.

d. Experimental Design and Data Analyses - The total number of horses seen on the study area will be compared with the number estimated to be in the area by State and Federal agencies. This information

will provide a qualitative description of the status of feral horses in the study area.

5. Parameter 5 - Rabbit Abundance

a. Objectives and Rationale - Cottontail rabbits and jackrabbits occur on Tract C-a. Cottontails are a game species in Colorado and are hunted in the vicinity of Tract C-a. Regional populations of rabbits are not likely to be adversely affected by oil shale development on Tract C-a. Habitat modification programs proposed by RBOSP will provide additional food and cover for rabbits. If rabbit populations in the vicinity of Tract C-a increase dramtically during oil shale development activities (either because of normal population fluctuations or for other reasons), the rabbits could confound attempts to evaluate revegetation studies by eating new growth in the study plots.

The objective of monitoring the Tract C-a study area is to obtain indices of rabbit abundance in the RBOSP study area.

b. Hypothesis

H_o: There is no significant difference in rabbit abundance (between years) in the RBOSP study area.

c. Methods - The roadside count method (Lord, 1963; Overton, 1971) will be used. Predetermined routes will be driven at a speed of approximately 10 miles per hour by the vehicle driver and an observer. All rabbits observed will be noted; cottontails and jackrabbits will be recorded separately.

d. Experimental Design and Data Analyses - Data collected during the first year will provide information regarding the optimum time of day, times(s) of year, length of routes, and number of replications required to obtain estimates of total rabbits, cottontails, and jackrabbits seen per mile of census route (within 20 percent of the

mean, 80 percent of the time). During the first year, counts will be made semi-annually, within 2 hours of sunrise or sunset, and over at least 50 miles of roads. The sampling program will be revised as needed after the first year study.

The number of rabbits seen per mile of census route will be compared between years (F-test). If data collected are sufficient (i.e., numbers observed are high enough), the number of rabbits observed per mile of each dominant habitat type, and/or number of cottontails and jackrabbits observed per mile of census route will be compared statistically.

CHAPTER 5
AQUATIC ECOLOGY

An analysis of 2 years of aquatic baseline data (RBOSP Final Environmental Baseline Report, 1977) and of the potential effects of Tract C-a development on aquatic communities indicates that certain aquatic communities and certain physical parameters will provide monitoring data sufficient to assess natural and impact-related trends in the aquatic ecosystems during the RBOSP development program.

Aquatic baseline data indicate that the major sources of autochthonous primary production in the aquatic habitats of the area is the periphyton. The primary consumers in aquatic habitats on or near Tract C-a are mostly benthic macroinvertebrates.

Because of their dominant role in the aquatic ecosystems of Tract C-a and vicinity, and because of their limited mobility and thus their susceptibility to physical and chemical changes, the benthos and periphyton communities will be included in future monitoring programs. The abundance, species composition, and diversity of these organisms will be evaluated to assess trends due to natural or man-induced variations.

Non-biological parameters to be included in the aquatic ecological monitoring program include water temperature, dissolved oxygen, pH, specific conductance, flow, velocity, depth, width, turbidity, substrate type, alkalinity, suspended solids, and total dissolved solids. The chemical parameters included in the RBOSP monitoring program are discussed under Hydrology, Surface Water Monitoring (Section 8, Chapter 6).

5.1 AQUATIC STUDIES DESIGN

Sampling sites for aquatic ecology monitoring studies were selected by assessing the potential impacts of development on aquatic sites used

during the baseline period. Sites likely to be affected and control sites were chosen. On and near Tract C-a, two aquatic habitat types have been observed: ponds and spring brooks. Based upon the analysis of baseline data and the potential impacts upon aquatic habitats, the following baseline sampling sites (Figure 8-5-1) were selected for monitoring:

- Station 5 (pond habitat) in Stake Springs Draw.
- Station 7 (spring brook habitat) at the USGS gaging station in Corral Gulch (west).
- Station 13 (spring brook habitat) at the USGS gaging station in Corral Gulch (east).
- Station 14 (pond habitat) in Corral Gulch (east).

In addition, sampling sites on Yellow Creek and the White River were selected to monitor the effectiveness of RBOSP water quality control plans and the potential impact of development. These sampling sites are:

- Station 20 (spring brook habitat) at the USGS gaging station on Yellow Creek.
- Station 22 (spring brook habitat) on Yellow Creek just above confluence with White River.
- Station 23 (back channel habitat) in the White River.
- Station 27 and 29 (back channel habitats) near the confluence of Yellow Creek with the White River.
- Station 35 (riffle habitat) in the White River.

Sampling frequency, at least initially, will be five times a year to allow comparison of monitoring and baseline data.

Hypotheses will be tested using statistical analyses appropriate to each parameter. The general analytical approach will consist of analyzing the specific abiotic and biotic parameters to determine whether temporal and spatial variations larger than those in the baseline analyses are present.

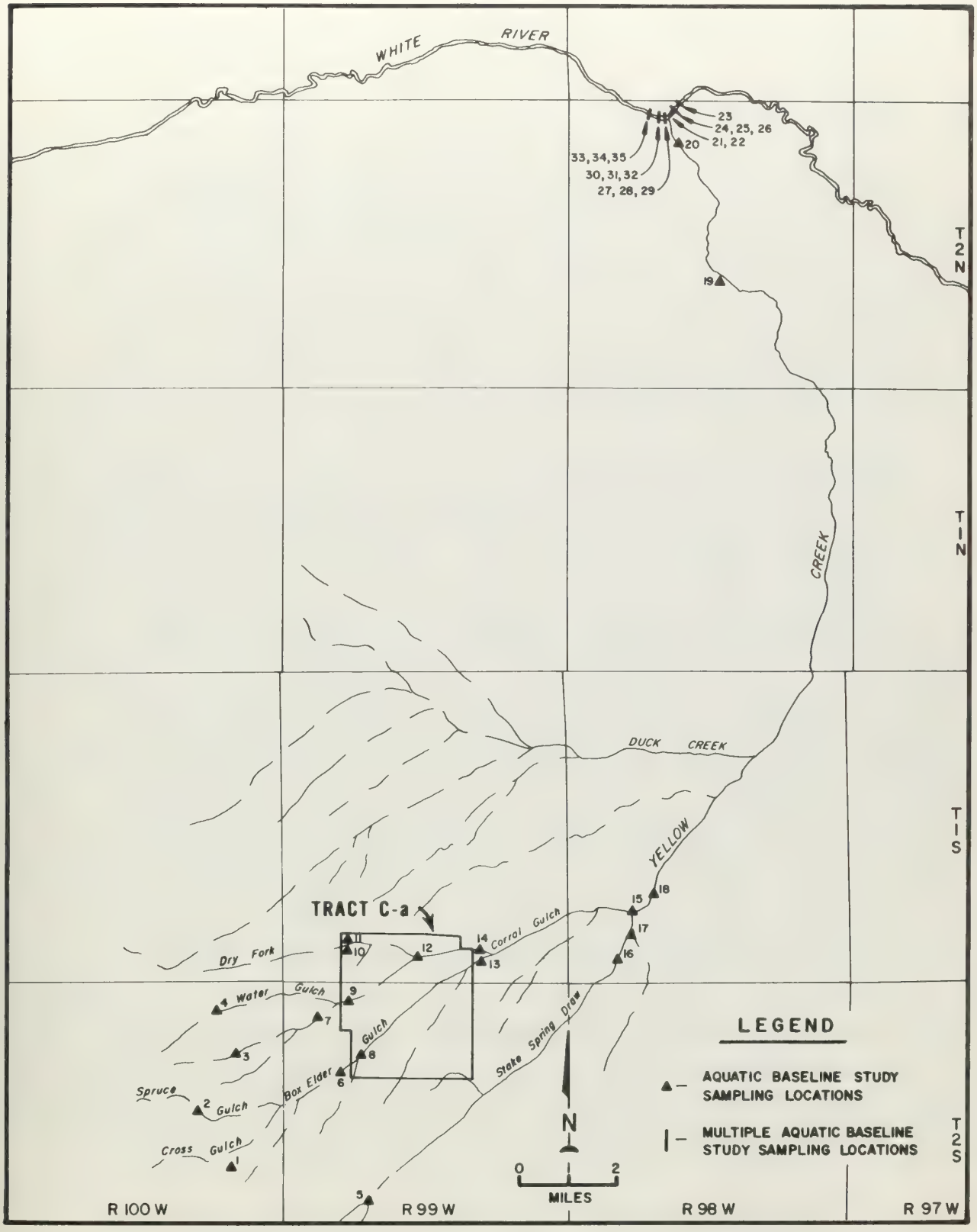

Figure 8-5-1

RBOSP AQUATIC SAMPLING LOCATIONS

5.2 ABIOTIC MONITORING

A. Physical Measurements

1. Objectives - The objectives of this aspect of the Aquatic Monitoring Studies will be to monitor selected physical characteristics of the streams at each sampling site and to relate these characteristics to baseline chemical and biological conditions. The physical measurement program will also include those chemical parameters which are measured in conjunction with field sampling operations. In fulfilling these objectives, the following hypotheses will be tested:

H_o: There is no significant difference in the physical characteristics of surface waters between the baseline and the development monitoring periods.

2. Methods - The following methods will be used to determine selected physical characteristics at each sampling site. These determinations will be made concurrently with the collection of chemical and biological samples. Stream velocity will be measured with a Gurley flowmeter or equivalent. The stream substrate will be visually classified at each station at the same time as benthic samples are collected. The turbidity of each sample will be determined with a Hach Photometric Turbidimeter or equivalent. Field measurements of dissolved oxygen will be taken with a portable dissolved oxygen meter or with the Alsterberg (Azide) modification of the Winkler Method (APHA, 1971).

Other parameters (and methods of measurement) which will be determined in the field include pH (portable meter), specific conductance (portable meter), water temperature (thermister or equivalent), depth, width, and alkalinity (colorimetric; APHA, 1971).

3. Rationale - The physical parameters selected for these monitoring studies are those which may be influenced by development (e.g., increased siltation and turbidity, decreased flows) and which have been shown to

be of particular importance to the aquatic organisms observed during baseline studies.

4. Data Analysis - Hypotheses will be tested using analysis of variance techniques. Sampling will be performed to achieve an accuracy of $\pm 2\sigma$ of the mean 80% of the time.

B. Water Quality

1. Objectives - The objectives of this aspect of the aquatic monitoring studies will be to monitor those chemical characteristics which baseline data analyses (RBOSP Final Environmental Baseline Report, 1977) have shown to contribute most to the natural variability in White River water quality and which should therefore provide a basis for assessing natural and man-induced variability in water quality. Water quality studies in other surface waters are discussed under Hydrology, Surface Water Quality (Section 8, Chapter 6). In fulfilling the above objectives, the following hypotheses will be tested:

H_o: There is no significant difference in the water quality characteristics of the White River between the baseline and development monitoring periods.

H_o: There is no significant difference in the water quality characteristics among sample sites.

2. Methods - Water quality parameters to be measured will include calcium, chloride, boron, fluoride, magnesium, potassium, sodium, sulfate, nitrate, orthophosphate, total phosphate, and silica. Baseline data analysis has shown that these parameters reflect a large amount of the natural variability of the White River. The nutrient parameters, nitrate, orthophosphate, total phosphate, and silica are included for their potential significance to biological productivity.

3. Rationale - The water quality parameters selected have been shown to contribute most to the natural variability in White River water

quality in the study area. Thus, measurement of these parameters during the Modular Development Phase should allow an evaluation of natural and development-related variability.

4. Data Analysis - Hypotheses will be tested using analysis of variance techniques. Sampling will be performed to achieve an accuracy of $\pm 2\sigma$ of the mean 80% of the time.

5.3 BIOLOGICAL MONITORING

A. Periphyton

1. Objectives - The objectives of periphyton studies will be to monitor periphyton species composition, relative abundance and diversity to assess the effects of development on periphyton communities. In fulfilling these objectives, the following hypotheses will be tested:

H_o: There is no significant difference in the relative abundance of periphyton between the baseline and development monitoring periods.

H_o: There is no significant difference in periphyton diversity between baseline and development monitoring periods.

H_o: There is no significant difference in the relative abundance of periphyton among sites.

H_o: There is no significant difference in periphyton diversity among sites.

2. Methods - Replicate samples will be collected at each sampling site from natural substrates and analyzed to determine relative abundance, diversity, and biomass. Field and laboratory methods will be the same as those used during baseline studies.

3. Rationale - Because periphytic algae constitute the major source of autochthonous primary production in the aquatic habitats of

the area, because they are non-motile and are thus susceptible to physical and chemical perturbations, and because measured changes in species composition, standing crop, and diversity can be used to assess the effects of development (such as increased siltation), periphyton studies will be included in the RBOSP development monitoring program.

4. Data Analysis - Hypotheses will be tested using analysis of variance techniques. Sampling will be performed to achieve an accuracy of $\pm 2\sigma$ of the mean 80% of the time.

B. Benthos

1. Objectives - The objectives of the benthos (macroinvertebrates) studies during the monitoring program will be to monitor benthic species composition, abundance, and diversity to assess the effects of development on benthos communities. In fulfilling these objectives, the following hypotheses will be tested:

H_o: There is no significant difference in the relative abundance of benthic macroinvertebrates between the baseline and development monitoring periods.

H_o: There is no significant difference in benthic diversity between the baseline and development monitoring periods.

H_o: There is no significant difference in the relative abundance of benthic macroinvertebrates among sites.

H_o: There is no significant difference in benthic diversity among sites.

2. Methods - At each station, samples will be collected with a modified Surber sampler or an Ekman grab, depending on the characteristics of the particular station.

After collection, benthos samples will be washed in buckets with bottoms fitted with a U.S. Standard No. 30 sieve, and preserved with neutralized 10% formalin. Laboratory methods will be those used during aquatic baseline studies.

3. Rationale - Because benthic macroinvertebrates constitute the major component of the secondary trophic level in aquatic ecosystems on and near Tract C-a, and because of their limited mobility and consequent susceptibility to physical and chemical changes, the benthic community is included in the RBOSP development monitoring program.

4. Data Analysis - Hypotheses will be tested using analysis of variance techniques. Sampling will be performed to achieve an accuracy of 2σ of the mean 80% of the time.

CHAPTER 6
HYDROLOGY

This proposed hydrology monitoring program is based on the data collected during the 2-year baseline program. These data have been studied using statistical methods including frequency analysis, scattergram analysis, bivariant correlation, factor analysis, discriminant function, and trend analysis. These studies are summarized in the Final Environmental Baseline Report and presented in detail in the appendices of RBOSP Progress Report 10.

The data collected during this monitoring program will be compared to baseline data using the same statistical methods as those used for the baseline data. If anomolies are indicated, the source of the anomaly will be analyzed through the statistical methods described above. These analyses will be used to determine both changes in the baseline hydrology as well as possible hydrologic environmental effects. With the commencement of tract developemnt, new information may become available which could indicate a need for a modification in this proposed monitoring program. Table 8-6-1 summarizes the hydrology monitoring program.

6.1 SURFACE WATER MONITORING

A. Springs and Seeps

1. Objectives - The objectives of monitoring and observing major springs and seeps during development activities will be to determine if their flows and conductivity will be affected by dewatering and reinjection.

2. Methods - One of the best methods to measure flowing water is via a weir or a flume. Therefore, one of these devices will be installed at six major springs and seeps located around Tract C-a. These measurements

Table 8-6-1

SUMMARY HYDROLOGY MONITORING PROGRAM

	Continuously or Automatically	Quarterly	Semi-Annually	Periodically
SURFACE WATER				
7 Stream Gaging Stations				
Sediment	X			
Conductivity	X			
Temperature	X			
Flow	X			
Limited water quality	X	X		
Baseline water quality	X		X	
6 Springs and Seeps				
Flow				X
Conductivity				X
GROUND WATER				
10 Alluvial Holes				
Water levels	X (4)	X (10)		
Limited water quality		X		
Baseline water quality			X	
11 Dual Aquifer Monitor Holes				
Water levels	X (11)			
14 USGS Monitor Holes				
Water levels				X
Dewatering Wells				
Flow	X			
Conductivity	X			
Pumping water level	X			
Baseline water quality			X	

( ) indicates the number of sampling sites.

will be made periodically as approved by the AOSS. The rationale for measuring flows from springs and seeps is based upon the 2-year baseline studies, which indicate that four of the six springs and seeps studied in detail are hydrologically connected to the upper oil shale aquifer. At this time, there is not sufficient data to determine how many of the 37 springs and seeps inventoried are connected to the upper oil shale aquifer. An analysis of structural geology related to spring and seep locations indicates that approximately half (Figure 7-6-1, Section 7, Chapter 6) may be affected by dewatering.

B. Surface Water

1. Objectives - The objectives of surface water monitoring will be to determine if surface water quantity and quality will be affected by Tract C-a development.

2. Methods - The methods of monitoring surface water quantity and quality will be through the use of seven of the same surface water gaging stations used to determine the hydrologic baseline. Conductivity, temperature, and flow will be monitored on a continuous basis, and sediment discharge will be monitored automatically.

3. Experimental Design and Rationale - The Final Baseline Report summarizes the 2 years of baseline data and analysis. The data were prepared and reported in Progress Report 2 through 10. Progress Report 10 Appendix presents the detailed statistical analysis summarized in the Final Baseline Report. As shown on Figures 8-6-1, 8-6-2, 8-6-3, and 8-6-4, mean daily flow, daily temperature, specific conductance, and suspended sediment duration curves are presented, respectively for each of the four stream gaging stations that had significant flows. If the continuous or automatically recorded parameters were to exceed the one percent value for over three days continuously, the water was sampled for the five parameters and the major ions discussed below in order to determine from which of the aquifer sources, if any, the anomaly had resulted. If it was determined that the anomaly was due to some other activity, then the complete baseline analysis was conducted.

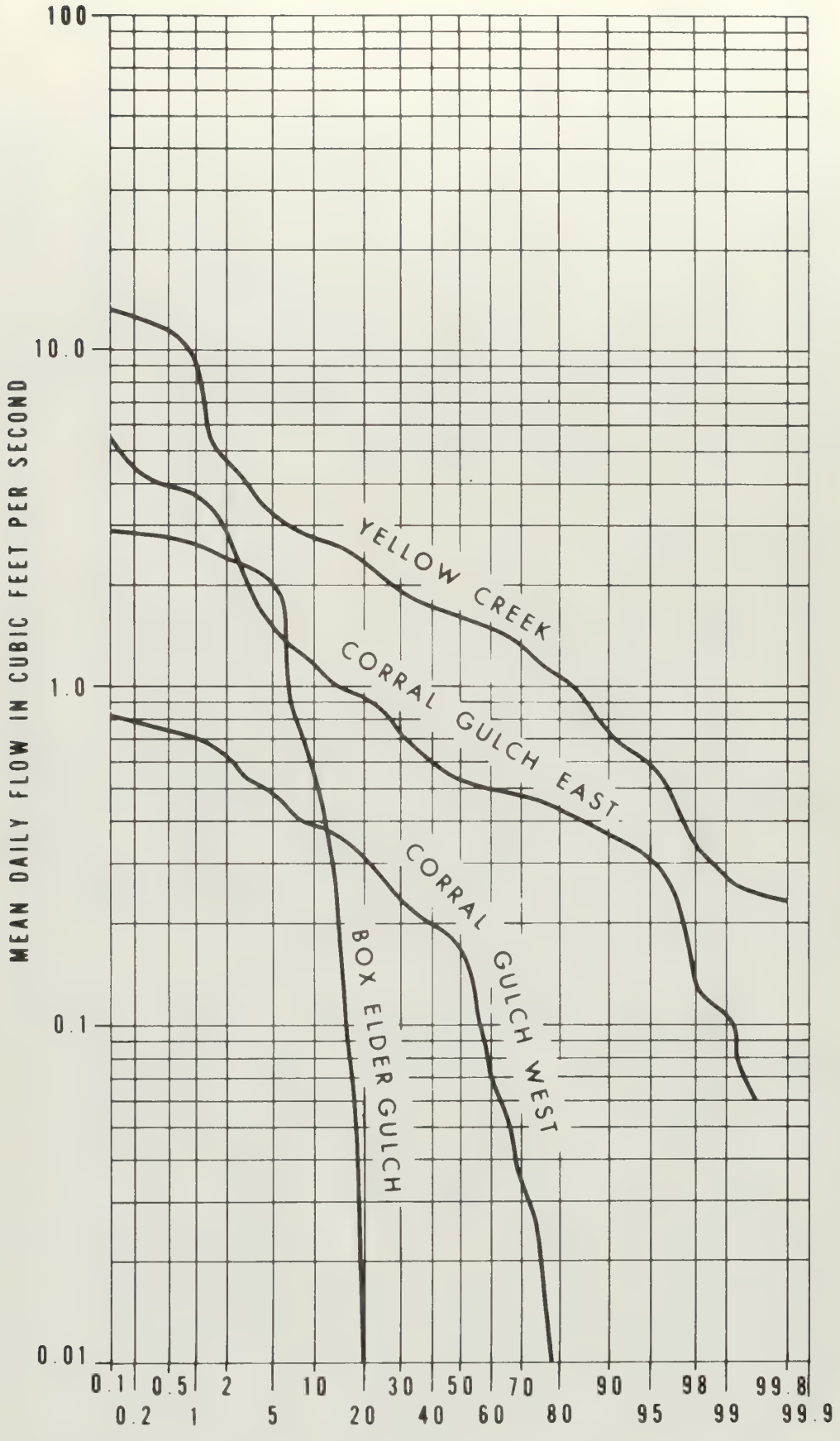
100
10.0
1.0
0.1
0.01
MEAN DAILY FLOW IN CUBIC FEET PER SECOND
YELLOW CREEK
CORRAL GULCH EAST
CORRAL GULCH WEST
BOX ELDER GULCH
0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9
PERCENT OF TIME INDICATED DISCHARGE WAS EQUALED OR EXCEEDED

Figure 8-6-1

FLOW DURATION CURVES TRACT C-a, MARCH, 1974 - OCTOBER, 1976

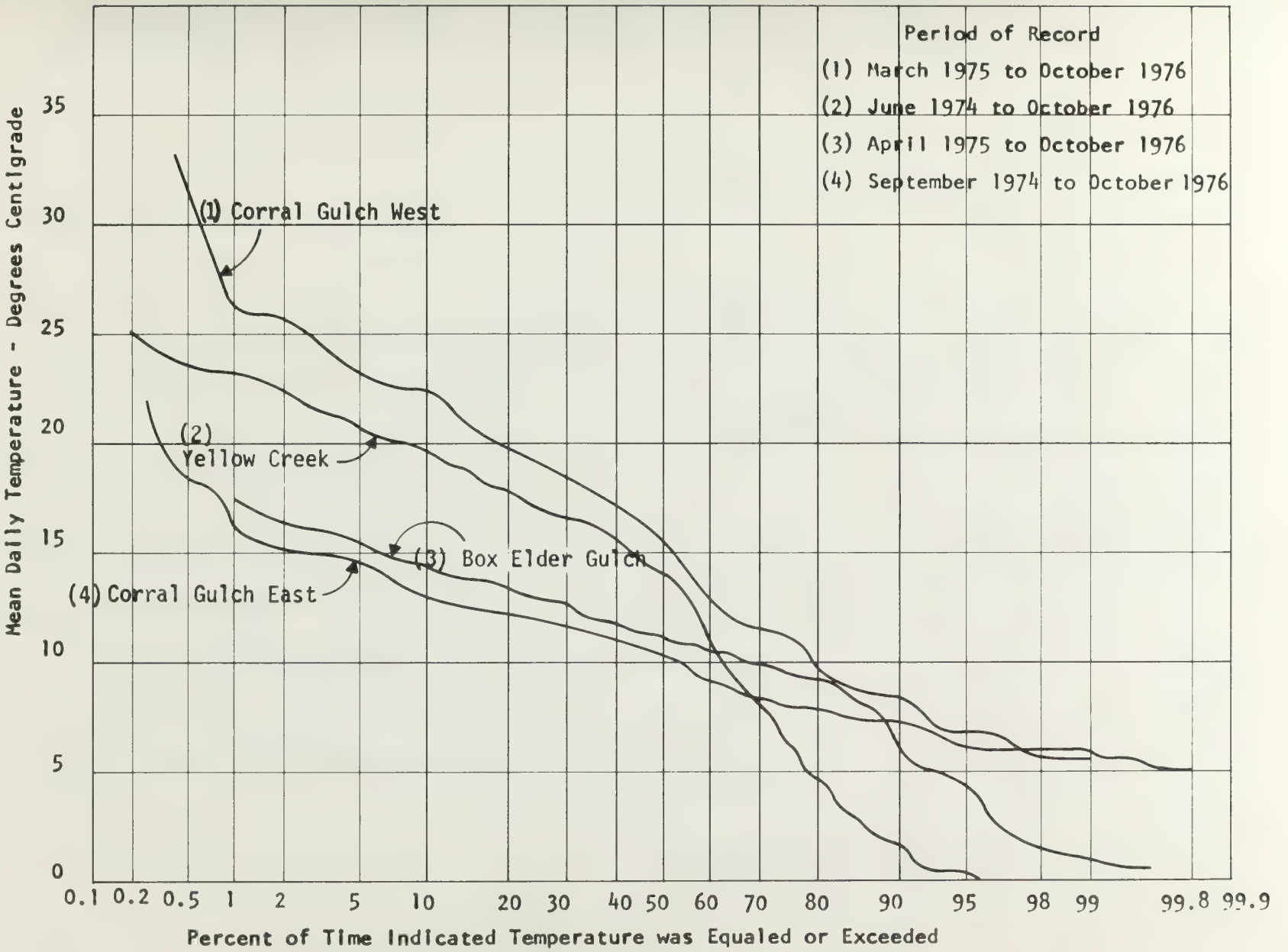
Period of Record
(1) March 1975 to October 1976
(2) June 1974 to October 1976
(3) April 1975 to October 1976
(4) September 1974 to October 1976
(1) Corral Gulch West
(2) Yellow Creek
(3) Box Elder Gulch
(4) Corral Gulch East
Mean Daily Temperature - Degrees Centigrade
0
5
10
15
20
25
30
35
0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9
Percent of Time Indicated Temperature was Equaled or Exceeded

Figure 8-6-2

MEAN DAILY TEMPERATURE DURATION CURVES, TRACT C-a MONITORING STATIONS

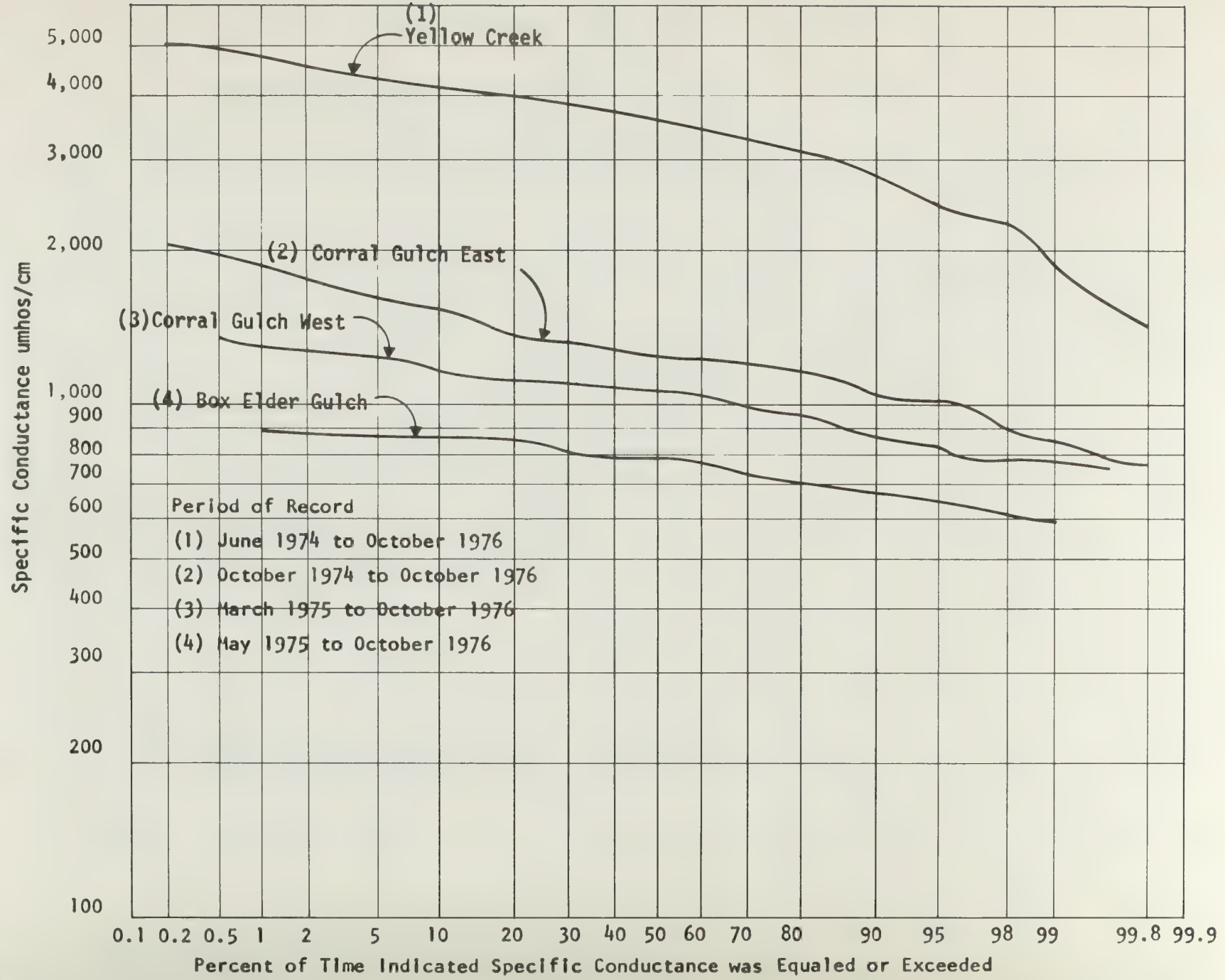

Figure 8-6-3

SPECIFIC CONDUCTANCE DURATION CURVES, TRACT C-a MONITORING STATIONS

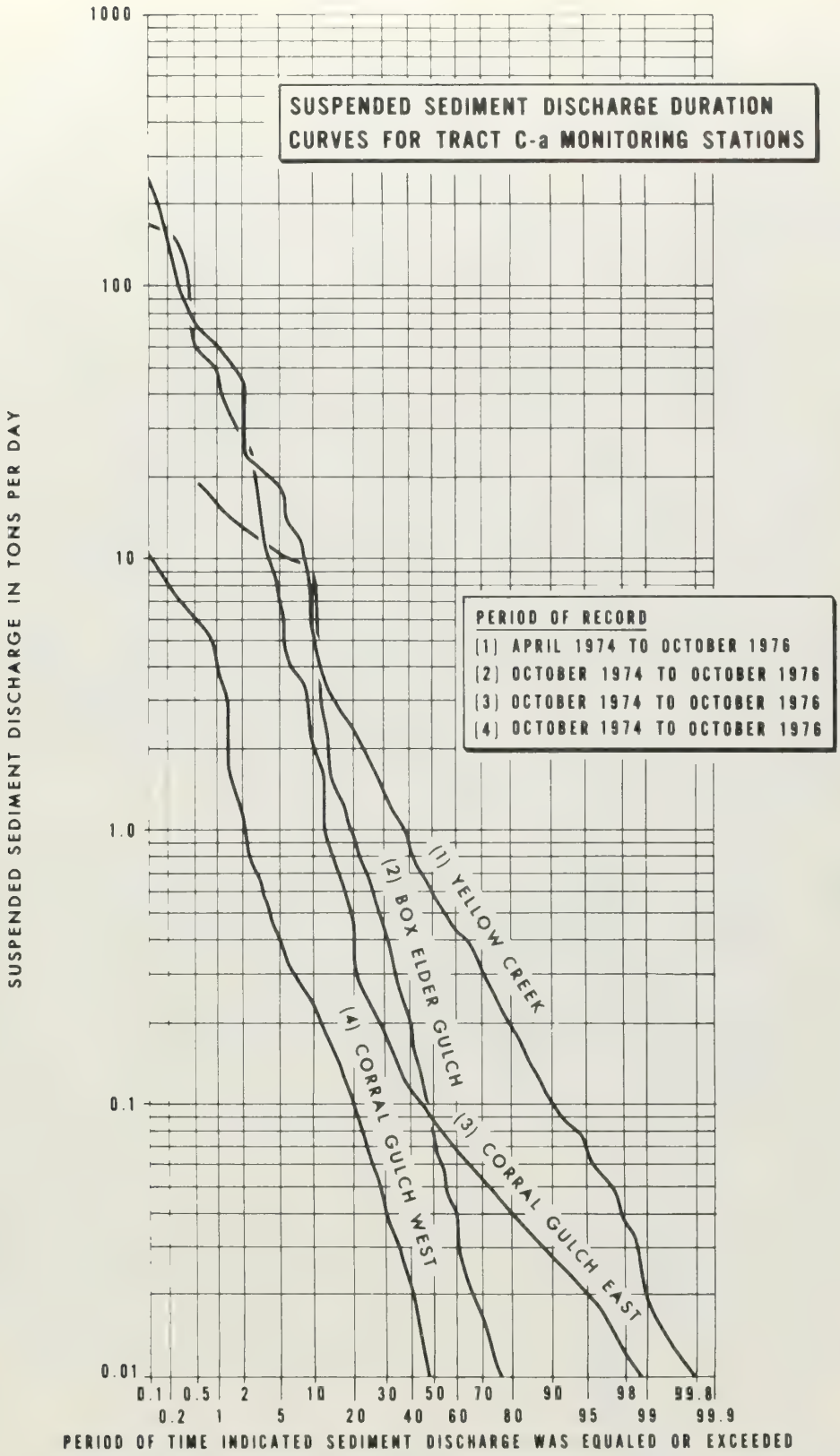
SUSPENDED SEDIMENT DISCHARGE DURATION CURVES FOR TRACT C-a MONITORING STATIONS
PERIOD OF RECORD
(1) APRIL 1974 TO OCTOBER 1976
(2) OCTOBER 1974 TO OCTOBER 1976
(3) OCTOBER 1974 TO OCTOBER 1976
(4) OCTOBER 1974 TO OCTOBER 1976
(1) YELLOW CREEK
(2) BOX ELDER GULCH
(3) CORRAL GULCH EAST
(4) CORRAL GULCH WEST
SUSPENDED SEDIMENT DISCHARGE IN TONS PER DAY
1000
100
10
1.0
0.1
0.01
0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9
PERIOD OF TIME INDICATED SEDIMENT DISCHARGE WAS EQUALED OR EXCEEDED

Figure 8-6-4

SUSPENDED SEDIMENT DISCHARGE DURATION CURVES

Discriminant function analysis was used to develop classification equations to allow identification of the source aquifer for unknown samples from Tract C-a. All analyses from the groundwater quality baseline monitoring program were used to develop the discriminating equations. The equations were developed using the criterion that maximum separation occurs between groups that were defined by the source of the sample. The contribution of a given variable to the discriminating power of the equation is shown by the magnitude of the discriminant coefficient. Once the discriminant function is developed for the samples with a known source, it can be applied to samples with an unknown source (i.e. surface water or spring samples) to get the most probable source for the sample in question. The efficiency of the classification function is measured by the percent of samples from a known source that are correctly classified. The function based on concentrations of alkalinity, sodium, silica, fluoride and pH was used to correctly classify 85 percent of the samples from known sources. If the upper aquifer and alluvial aquifers are grouped, then the discrimination of lower aquifer water approaches 90 percent probability of success.

The major ions found during the baseline in the various waters have been plotted on trilinear diagrams. As shown on Figure 8-6-5 the catagorization of waters by Ca, Mg, SO_4, Cl, K, HCO_3, and CO_3 plus SiO_2 and F from above allows for additional comparison of water types. These major constituents will be analyzed along with the five parameters and will be measured quarterly and used for a cation-anion balance as quality control check on the lab work.

As the potential by-products, gases, and other possible inputs to a hydrologic system are known, these parameters may be included in the monitoring program. Additional knowledge of possible inputs will be gained during the early portion of the Modular Development Phase.

Provided no change in baseline is detected, the complete suite of baseline constituents (Table 8-6-2) will be analyzed from each of the gaging

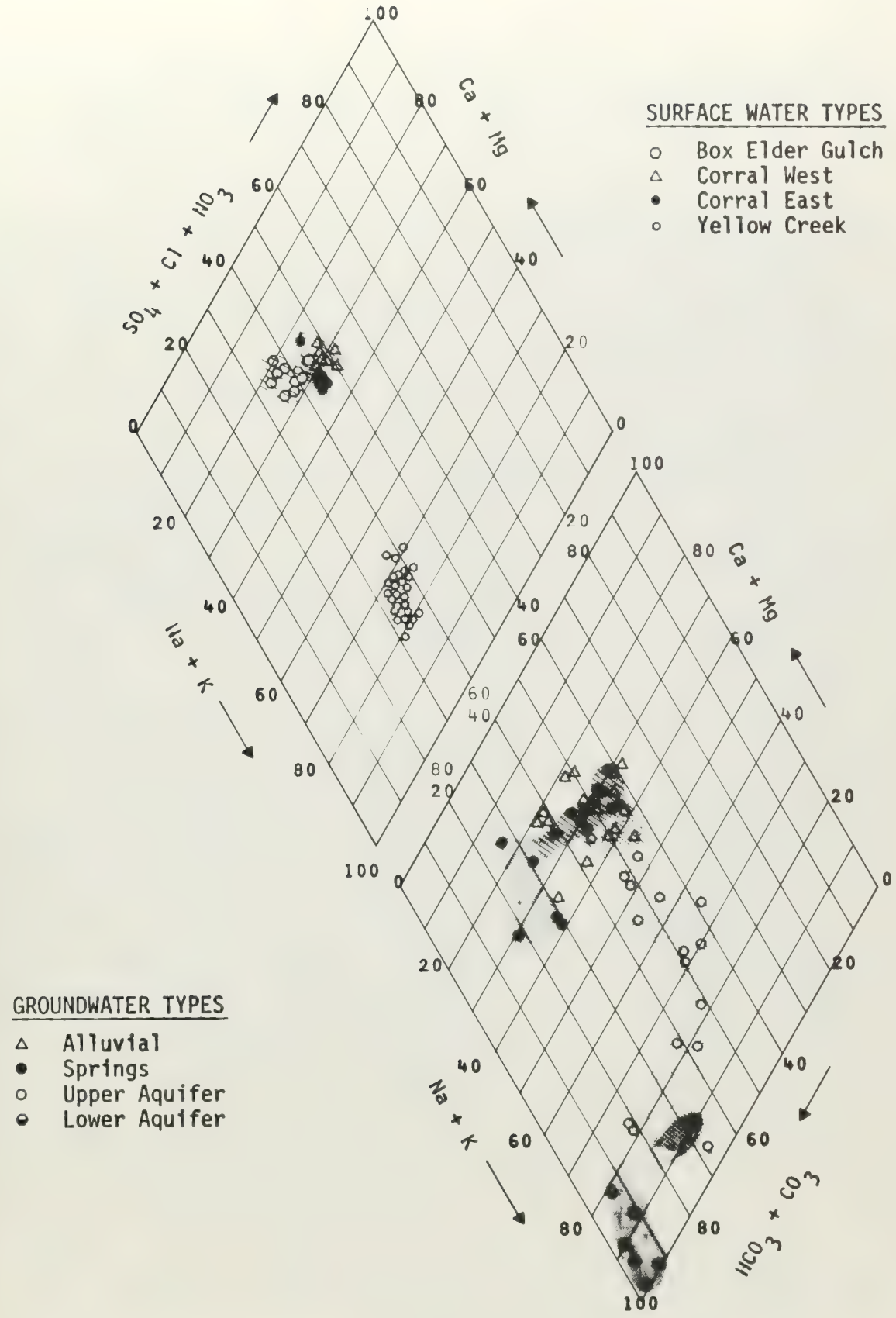

Figure 8-6-5

TRACT C-a and VICINITY SURFACE AND GROUNDWATER TYPES

Table 8-6-2

BASELINE DATA COLLECTION FOR STREAM GAGING STATIONS

Continuously or Automatically

Flow Rate
Sediment Discharge
Temperature
Specific Conductance

Water Samples Analyzed For:

Alkalinity
Biological Oxygen Demand
Dissolved Organic Carbon
Boron
Calcium
Conductance
Fluoride
Magnesium
Potassium
Silica
Sodium
Sulfate
Ammonia
Bicarbonate
Carbonate
Chloride
Color
Dissolved Solids
Kjeldahl Nitrogen
Nitrate plus Nitrite
Odor
Dissolved Phosphate
Turbidity
Dissolved Oxygen
pH
Temperature
Total Phosphate
Ortho Phosphate
Suspended Organic Carbon

COD
Fecal Coliform
Pesticides
Polycyclic Aromatics
Total Coliform
Bromide
Cyanide
MBAS
Oil & Grease

Phenols
Sulfide
Radioactivity
  Gross Alpha
If >4pci/l
Then Ra^{226}
  Natural Uranium
  Gross Beta
If >100 pci/l
Then Sr^{90}
  Ce^{137}

Ba
Be
Ge
Ga
Ni
Ti
V
Zr
Al
As

Cd
Cr
Cu
Fe
Pb
Li
Mn
Mo
Hg
Se
Sr
Zn

stations on a semi-annual basis during the spring and fall of each year if continuous flow occurs; or at least twice a year during flow events in ephemeral streams.

The purpose for running the complete baseline analysis twice a year is to determine if: 1) the baseline has changed significantly from the first 2 years of data, or 2) that the quality of the surface water has been affected by oil shale activities on Tract C-a. It is felt that the monitoring of conductivity, temperature, and flow on a continuous basis, the quarterly monitoring of the major ions, sodium, fluoride, silica, pH, and alkalinity and the semi-annual analyses for the complete baseline constituents will be sufficient to determine if the baseline parameters have changed.

6.2 GROUNDWATER MONITORING

A. Alluvial Aquifers

1. Objectives - The objectives of monitoring the alluvial aquifers will be to determine if: 1) conditions have changed since the baseline data were collected, and 2) to detect if the alluvial aquifers have been affected by spills.

2. Methods - During the baseline period, a total of seven shallow alluvial monitor holes were drilled and monitored. The data collected from this alluvial monitoring program have been presented in Progress Reports 2 through 10, and are summarized and analyzed in Progress Report 10 Appendix and the Final Baseline Report. The monitoring of these seven holes plus three new alluvial holes shown on Figure 8-6-6 will sufficiently meet the objectives of this program.

Continuous water level recorders will be installed in the three new monitor holes plus G-S S-14. In addition, samples will be collected and analyzed quarterly for the five quarterly parameters, conductivity,

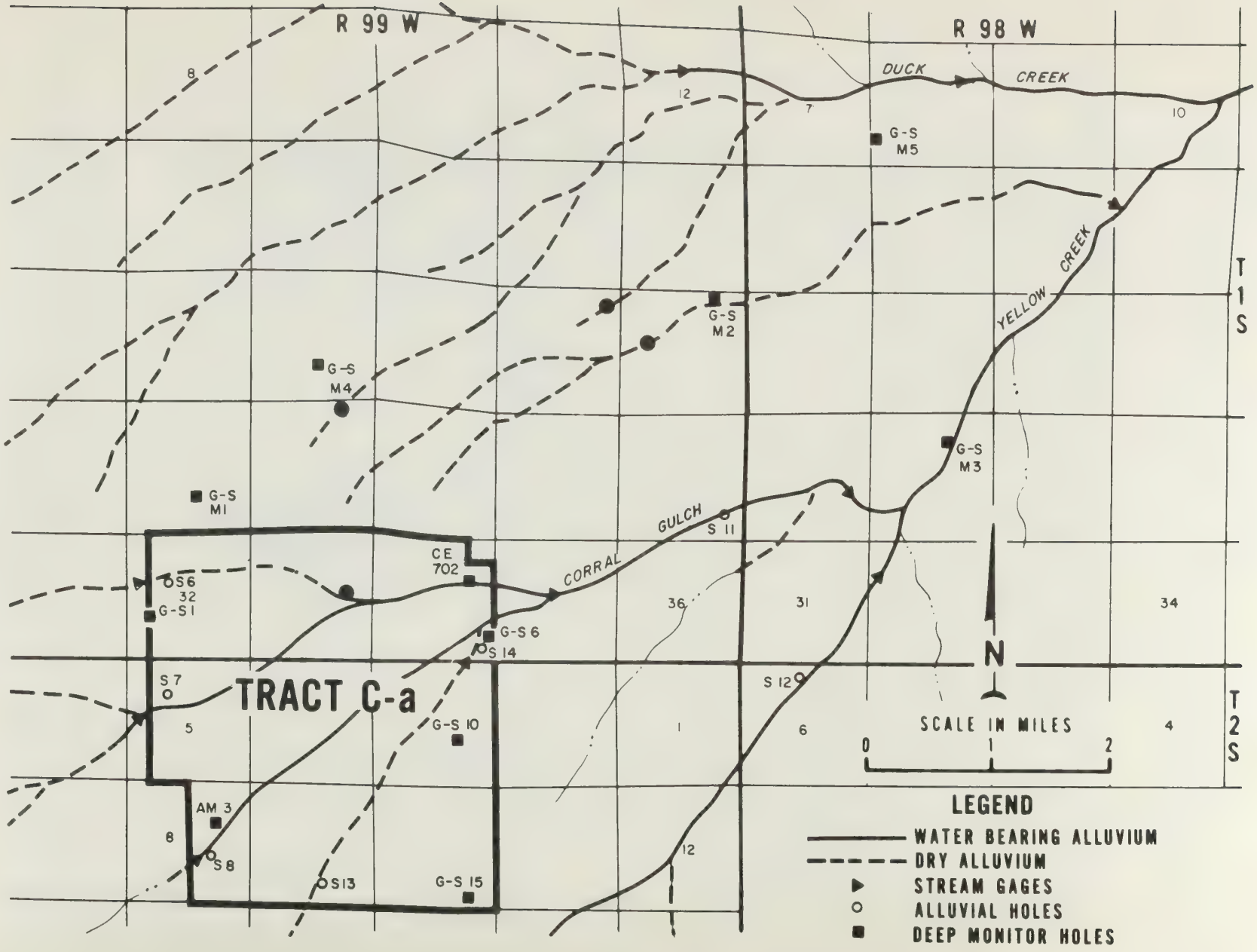

Figure 8-6-6

LOCATIONS OF STREAM GAGING STATIONS AND WATER MONITORING HOLES

temperature, and the major ions as listed in the surface water monitoring program. These alluvial holes will also be sampled and analyzed for the baseline constituents twice a year as indicated in Table 8-6-3.

Two new alluvial holes will be located below the "downstream" of the proposed retention ponds for 1) the surface processing area and 2) the mine shaft area. The third new alluvial hole will be located on Corral Gulch and is "downstream" of all surface disturbances. The existing hole (G-S S-14) in the Rinky Dink Gulch alluvium will be used to monitor the spent shale runoff retention pond.

B. Deep Oil Shale Aquifers

1. Objectives - The purpose for this groundwater monitoring program will be to measure water levels in the upper and lower oil shale aquifers and to monitor any possible changes in water quality, and determine the accuracy of the RBOSP Piceance Creek hydrologic model.

2. Methods - During the Modular Development Phase, at least initially, recorders will be installed in a number of the dual aquifer monitoring holes and G-S M 5 and these will be monitored weekly in order to determine water level changes caused by dewatering and reinjection. The water level monitoring during the Commercial Phase will be reduced to monitoring the 11 permanent monitoring holes shown on Figure 8-6-6 and the USGS observation wells shown on Figure 8-6-7. Frequency will be monthly until trends are established. The dual aquifer monitor hole will also be used when needed.

New monitor holes will be established along the eastern tract boundary prior to the time CE 702, G-S 6 and G-S 10 are eliminated by mining.

Flow meters will be installed in the dewatering wells to determine the dewatering rate. In addition, measuring devices will be used to determine the pumping water level in each dewatering well. The details of the reinjection well monitoring plan have not been worked out at this

Table 8-6-3

BASELINE DATA COLLECTION FOR GROUND WATER

Semi-Annually

Water Sample Analyzed For:

Alkalinity
Aluminium
Ammonia
Arsenic
Ba
Be
Bi
Bicarbonate
Br
B
Dissolved Organic Carbon
Calcium
Carbonate
Cd
Chloride
Cr
Cu
Cyanide
COD
Dissolved Solids
Ge
Ga
Fluoride
Iron
Lead
Li
Mg
Mn
Hg
Mo
Ni
Nitrate plus Nitrite
Phenols
Dissolved Phosphate
Pottassium
Se
Silica
Na
Sr
Sulfate
Sulfide
Ti
V
Zr
Zn
Color
Odor
pH
Temperature
Conductance

Radioactivity
Gross Alpha
If >4 pci/l
Then Ra^{226}
Natural Uranium
Gross Beta
If >100 pci/l
Then Sr^{90}
Ce^{137}

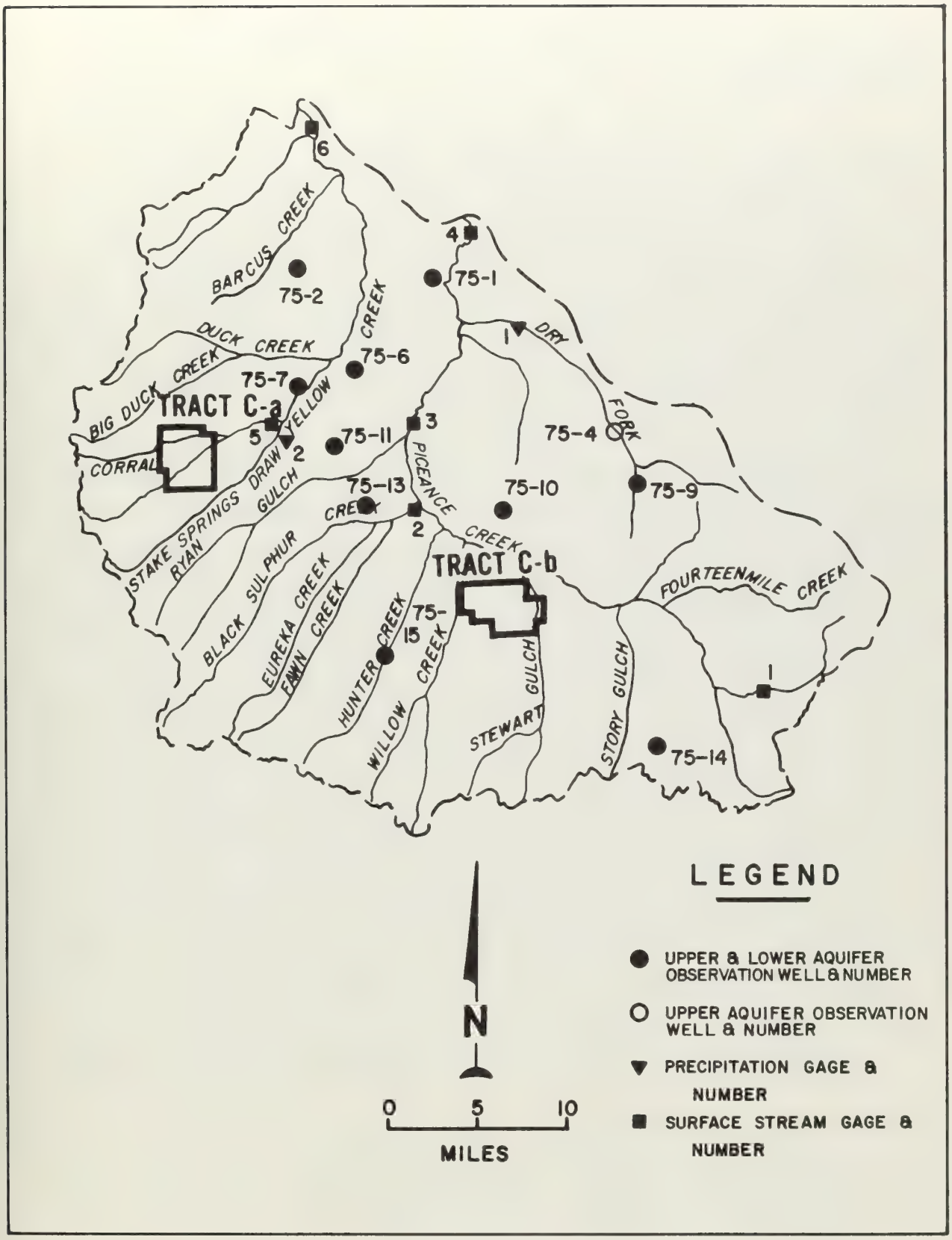

Figure 8-6-7

RBOSP WATER AUGMENTATION PLAN MONITORING PROGRAM

time, but it is anticipated that injection rates and water quality will also be monitored.

The water quality monitoring of the deep oil shale aquifers will be largely limited to the dewatering well and mine drainage discharges. Continuous conductivity and temperature measurements will be made prior to reinjection. Initially, the baseline constituents will be analyzed on a monthly basis until either a definite trend or a stabilization of the major constituents is observed. Thereafter, the baseline constituents will be analyzed twice a year or when significant changes are observed in the conductivity values.

3. Rationale - The rationale for water quality monitoring of the discharges only is based on the fact that a cone of depression will be created by dewatering. Water entering these two aquifers from Tract C-a during dewatering will flow toward the dewatering wells and the mine. Therefore, any effects on water quality will be observed in the discharge waters.

CHAPTER 7
REVEGETATION

7.1 INTRODUCTION

RBOSP, in compliance with the spirit of the lease stipulations, will adopt the objective of reclaiming disturbed areas in such a way that the reestablished habitat will be of a quality equivalent to or better than that which existed before disturbance. Since the elevation and topography of the processed shale and raw shale disposal sites will cause micro-environmental regimes to differ from current conditions, deviation from the current species composition is expected. Changes in species composition, percent cover, and productivity will occur in revegetated areas as a result of succession. The final species composition is impossible to predict but will depend on 1) invading natural seed sources in the area, 2) viability and composition of planted species, 3) climatic conditions during succession, and 4) grazing by feral and domestic animals.

The area to be disturbed by RBOSP oil shale development is limited primarily to Tract C-a. The vegetation types on the tract consist primarily of pinyon-juniper, sagebrush scrub, and mixed brush. The subsequent revegetation will include varied seed mixtures and/or transplants which will provide a diversity of communities on varied slopes, aspects, and terraces. In addition, the seed mixtures selected will vary in accordance with the projected land uses to provide a balance of forage and browse plant species. Therefore, the reestablished communities will provide the diversity necessary to support animal life similar to that currently existing in the area.

Reestablishment of permanent vegetation of a quality which will support animal life similar to the presently existing fauna is the primary criterion for determining the success of the RBOSP revegetation efforts. Productivity and vegetation cover will be key characteristics in

determining the quality of the vegetation. Natural production of the dominant vegetation types on Tract C-a is 100 kg/ha in pinyon-juniper, 210 kg/ha in mixed brush, and 270 kg/ha in sagebrush scrub (RBOSP Final Environmental Baseline Report, 1977). It should be noted that these are average measurements for each vegetation type and do not reflect the natural variation which arises from slope and aspect. Productivity of the revegetated areas will vary according to the vegetation types established. In addition, the total percent cover of the vegetation types varies naturally (average cover of 35 to 40%) and a similar percent cover is expected for successfully revegetated areas. Other characteristics (e.g., soil stability and equitable distribution of vegetation) will further indicate the degree to which the objective of revegetation has been accomplished. Reproductive success will ultimately determine the self-sustaining capacity of the system and its long-term stability.

Available revegetation technology appears adequate to insure that quality wildlife habitat can be reestablished on Tract C-a. RBOSP is investigating specific aspects of revegetation technology to adapt available reclamation procedures to conditions at Tract C-a. (See Section 6, Chapter 8.4). The combination of available technology and the information gained through RBOSP's experimental revegetation program indicate that RBOSP can successfully demonstrate the necessary technology by the tenth year after approval of the DDP.

7.2 MONITORING PROGRAM

The overall objective of the revegetation monitoring program is to insure that successful, self-sustaining, and desirable revegetation occurs wherever practicable on lands disturbed by RBOSP development operations, in accordance with the lease stipulations. This monitoring program will provide the necessary data to determine if the criteria of revegetation success have been successfully met.

Areas disturbed along roads, around buildings, and within corridors will be monitored qualitatively. Revegetation efforts in these areas will be considered successful when a self-sustaining vegetative cover which is equivalent in percent cover to the surrounding vegetation is established. Surface disturbed areas will be evaluated in cooperation with the AOSO and any areas not successfully revegetated will be reseeded.

The monitoring program will emphasize the revegetated processed shale and raw shale ore disposal piles since these areas will be the most difficult to revegetate. During the Modular Development Phase, approximately 325 acres of the raw shale ore disposal pile (65 acres east of the compressor area and 260 acres west of the processed shale pile) will require revegetation. In the Commercial Phase, there will be no disposal of raw shale ore since all shale ore will be processed in the surface retorts. Surface retorting will result in the disposal of processed shale which will cover approximately 880 acres. The processed shale pile will be reclaimed in sections. Each of the two raw shale ore disposal piles or a completed portion of the processed shale pile will represent a "unit" of revegetated land which will be monitored. The quantitative sampling program will encompass the first five growing seasons after seeding.

Table 8-7-1 summarizes the parameters, sampling techniques, sampling frequency, and sampling intensity for the vegetation, soils, and faunal program to be conducted on the revegetated areas.

A. Vegetation

1. Parameter 1 - Range Productivity and Utilization

a. Objectives and Rationale - The revegetation program is designed to reclaim disturbed areas in such a way that the reestablished habitat will provide vegetation equivalent in quality to that which existed prior to disturbance. The range productivity and utilization

Table 8-7-1

SUMMARY OF THE REVEGETATION MONITORING PROGRAM FOR THE RAW SHALE ORE AND PROCESSED SHALE DISPOSAL PILE

Table 8-7-1

SUMMARY OF THE REVEGETATION MONITORING PROGRAM FOR THE
RAW SHALE ORE AND PROCESSED SHALE DISPOSAL PILE

Sampings Program	Parameter	Sampling Frequency	Sampling Technique	Sampling Intensity	Data Analyses
VEGETATION	Species Composition	Before Revegetation, Year 3,5...	Quadrat (9.6 sq ft)	1 Transect/40ha (100 acres) (10 quadrats each - 10m intervals)	Coefficient of Community (CC) Percent Similarity (PS) (Pielou, 1974)
	Percent Cover	Before Revegetation, Year 3,5...	Quadrat (9.6 sq ft)	1 Transect/40ha (100 acres) (10 quadrats each - 10m intervals)	Coefficient of Community (CC) Percent Similarity (PS) (Pielou, 1974)
	Productivity & Utilization	Before Revegetation, Year 3,5...	Double sampling method (USDA, 1970)	1 Transect/40ha (100 acres) (10 plots each)	Analysis of Variance (AOV); Multiple Range Test
	Browse Condition & Utilization	Before Revegetation, Year 3,5...	Cole (1963)	1 Transect/40ha (100 acres) (25 individual)	Analysis of Variance (AOV); Multiple Range Test
SOILS	pH Macronutrients (N,P,K) Micronutrients (Cl, Ca, Na)	Year 1,3,5...	Soil cores - (0-10cm;30-40cm)	1 sample/40ha (100 acres)	Qualitative Analysis of Variance (AOV); Multiple Range Test
	Conductivity Trace elements (Ar, B, Zn, Se, etc.)	Year 1,3,5...	Soil cores - (0-10cm;30-40cm)	1 sample/40ha (100 acres)	Analysis of Variance (AOV); Multiple Range Test
FAUNA	Small Mammals Species Composition Index of Abundance	Before Revegetation, Year 1,3,5...	Pit trapping Live trapping	5 Transects/unit (2 transects of 10 traps/group) *	Regression Analysis; F-test; Analysis of Variance (AOV) (Index of Abundance)
	Avifauna Species Composition Map of Territories Density of Breeding Birds	Before Revegetation, Year 1,3,5...	Breeding bird mapping technique (Graul, 1976; Hall, 1964; Robbins, 1970)	12-45 ha(30-105 acres) (depending on size of area) divided into 1 ha subunits; 8 replicates of subunits *	Regression Analysis; Analysis of Variance (AOV) (For density only)

* Adequate sample size will be determined during the first year.

studies will determine vegetation availability and use by wildlife in the revegetated areas for comparison to pre-existing conditions.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in the range productivity or range use between the experimental and control sites before revegetation; after revegetation.

H_o: There is no significant difference in range productivity or range use in the experimental site before and after revegetation; in the control site before and after revegetation.

c. Methods - Sampling will be conducted on experimental (revegetated) and control areas. Vegetation will be measured at the end of the growing season (September) in the year preceding disposal and in years 3 and 5 after revegetation. Vegetative productivity will be measured by the double sampling method (USDA, Region 2, 1970) (1 transect/10 acres of habitat). Transects will be selected randomly within the revegetated and control areas. Determination of adequate sample size, based on percent cover, indicates that 100 plots will achieve an accuracy of $\pm$25% of the mean 90% of the time.

Two caged plots (9.6 square feet in size), and eight unprotected plots (permanently marked) will be located along each sample transect. Sampling will be done using a 9.6 square foot sampling loop on each of 8 unprotected plots. Production of the dominant grass and forb species (species making up 90% of the individuals) within the loop will be estimated by ocular weight to the nearest gram. Species providing less than one percent biomass will be recorded as present, but will not be weighed. The two protected plots will be clipped, bagged separately, weighed green and recorded. Correction factors will be calculated from the estimated green weights and actual green weights of the clipped plots. Samples will then be air dried and weighed to obtain dry weights.

Potential vegetation damage from insect, frost, or gaseous emissions (SO_2 or NO_x) will be qualitatively assessed. Any damage will be recorded and an estimate of damaged vegetation will be calculated to determine the percent of the sampled vegetation which was affected.

d. Experimental Design and Data Analyses - Data collected on the control and experimental sites will be analyzed by an analysis of variance (AOV). Data collected before treatment will be used to test between site differences. After treatment, a two-way AOV will be used to compare treatment effects, time effects, and a treatment x time interaction. If the interaction effect is significant, a multiple range test will be performed to determine the source of the interaction.

2. Parameter 2 - Browse Utilization

a. Objectives and Rationale - Habitat which provides important browse for large herbivores will be disturbed by Tract C-a development. The browse utilization studies will determine browse availability and use by large herbivores for the revegetated area for comparison to pre-existing conditions.

b. Hypotheses - The following hypotheses will be tested:

H_o: There is no significant difference in browse utilization between the experimental and control sites before revegetation; after revegetation.

H_o: There is no significant difference in browse utilization in the experimental site before and after revegetation; in the control site before and after revegetation.

c. Methods - Sampling will be conducted on the experimental and control sites. Browse will be measured in early May (after deer have migrated through the Tract C-a area) in the year preceding disposal and after revegetation in years 3 and 5.

Browse utilization will be estimated along transects (1 transect/10 acres) consisting of 25 individual shrubs (Cole, 1963). Transects will be selected randomly within the experimental and control sites. Data collected during the first year will be used to determine the number of transects necessary to achieve an accuracy of $\pm$ 25% of the mean 90% of the time.

Browse species to be sampled could include, depending on the initial seeding mixture and plant invasion, juniper (Juniperus osteosperma), pinyon (Pinus edulis), antelope bitterbrush (Purshia tridentata), snowberry (Symphoricarpos oreophilus), big sagebrush (Artemisia tridentata), and true mountain mahogany (Cercocarpus montanus).

Form class, age, leader use, hedging and availability will be measured.

Potential vegetation damage from insect, frost, or gaseous emission (SO_2 or NO_x) will be qualitatively assessed. Any damage will be recorded and an estimate of damaged vegetation will be calculated to determine the percent of the sampled vegetation which was affected.

d. Experimental Design and Data Analyses - Data collected on the control and experimental sites will be analyzed by an AOV. Data collected before treatment will be used to test between site differences. After treatment, a two-way AOV will be used to compare treatment effects, time effects, and a treatment x time interaction. If the interaction effect is significant, a multiple range test will be performed to determine the source of the interaction.

3. Parameter 3 - Species Composition and Percent Cover

a. Objectives and Rationale - Species composition and percent cover in the revegetated areas will differ from adjacent, undisturbed areas. Species composition and percent cover studies will indicate the extent of invasion of plant species from surrounding areas and the progress of secondary succession within the revegetated area.

b. Hypothesis - No statistical hypothesis will be tested because a significant difference in species composition between the control and experimental sites after revegetation is expected due to planting.

c. Methods - Species composition and percent cover will be determined concurrently (before revegetation and at years 3 and 5) with the range productivity and utilization studies. The percent cover of each species in the 9.6 square foot plots (10 plots/transect and 1 transect/10 Acres) will be estimated and recorded. Sampling will be done to achieve an accuracy of $\pm$ 25% of the mean 90% of the time.

d. Experimental Design and Data Analysis - Data collected on the control and experimental sites will be compared before and after revegetation by means of a coefficient of community (CC) and a percentage simularity (PS) (Pielou, 1974). Comparisons before revegetation will be used to determine the degree of similarity between the control and experimental sites. Comparisons after revegetation should indicate a reduced similarity, but these measurements will indicate the extent of invasion of plant species from surrounding areas and the progress of secondary succession in the revegetated area.

B. Soils - The soil monitoring program was designed to collect data regarding the chemical characteristics of the plant growth medium. It is anticipated that soil temperatures in the artificial soil profile will not vary substantially from soil temperatures in the surrounding area. If initial revegetation efforts prove unsuccessful, soil temperature may be monitored to determine if insufficient processed shale cooling (i.e., increased soil temperature) appears to be a factor.

1. Parameter 1 - General Soil Properties

a. Objectives and Rationale - Chemical constituents which may potentially affect successful germination and establishment of the planted species will be monitored. Macronutrients will be monitored to provide additional information regarding fertilizer requirements.

b. Hypothesis - No hypothesis for general soil properties will be tested.

c. Methods - Soil samples will be collected in August (year 1, 3, and 5 after revegetation) from a revegetated unit. Each sample (1 sample/10 acres) will consist of subsamples collected from depth of 0-10 cm and 30-40 cm. Macronutrients (N, P, K), micronutrients (C1, Ca, Na) and pH will be analyzed by a commercial laboratory.

d. Experimental Design and Data Analyses - The results of the general soil property analyses will be averaged to indicate the general nutrient levels of the soils. These data will be used to determine fertilizer requirements; no impacts of oil shale development are expected to affect nutrient levels.

2. Parameter 2 - Trace Metals and Conductivity

a. Objectives and Rationale - The toxic properties of processed shale may affect the surface soils of the revegetated areas if the crushed rock layer is not successful in preventing upward capillary action. The trace metal and conductivity studies are designed to detect changes in conductivity levels or trace metal concentrations.

b. Hypothesis

H_o: There is no significant difference in conductivity or trace metal concentrations between the control and revegetated area.

c. Methods - Soil samples will be collected in August (year 1, 3, and 5 after revegetation) from the revegetated unit. Each sample (1 sample/10 acres) will consist of subsamples collected from depths of 0-10 cm and 30-40 cm. Conductivity and trace metals (Sb, As, B, Cd, F, Hg, Se, Mo, and V) will be analyzed by a commercial laboratory to determine if capillary movement from the processed shale or raw shale ore has

made these elements available in the plant root zone. If trace elements are higher in the revegetated area than the control area, then trace element measurements of vegetative material of the dominant plant species will be conducted to determine if trace elements have entered the vegetation. A detailed program of trace elements analyses in vegetation will be designed if significant accumulation in vegetation is indicated.

d. Experimental Design and Data Analyses - Data collected on the control and experimental sites will be analyzed by an AOV to test a difference between the control and revegetated areas.

C. Fauna

1. Parameter 1 - Small Mammal Abundance

a. Objectives and Rationale - A variety of small species have been found on Tract C-a. Small mammals are important components of the diets of many predators. Small mammals also act as seed dispersal agents and compete with other animals for certain food items. Oil shale development on Tract C-a should have no adverse impacts on regional small mammal populations. Habitat enhancement and revegetation programs proposed by RBOSP will increase the amount of food and cover available for certain species of small mammals.

The objective of small mammal monitoring studies is to evaluate the response of these species to the revegetation program proposed by RBOSP.

b. Hypothesis

H_o: Small mammal population levels are not significantly changed by revegetation.

c. Methods - Sherman live traps, baited with peanut butter and birdseed, will be used. Five trap groups (2 lines of 10 traps each) per sampling area will be used during the first year (see Subsection d).

The total number of trap groups and the number of sampling days required will also be determined during the first year. Traps will be checked twice a day (morning and evening) so that data for nocturnally and diurnally active species are obtained. Animals captured will be identified, sexed, aged (adult or immature) and released at the point of capture.

Pit-traps will also be used. Approximately 10 pit-traps will be established in each small mammal sampling area. These traps will be placed in locations where shrews or other small mammals might be captured.

d. Experimental Design and Data Analyses - Small mammal trapping will be conducted on revegetated and control areas before and after revegetation. Control areas will be established in habitat similar to that in areas to be revegetated. Sampling intensity (numbers of sampling areas and trap groups) sufficient to provide indices of small mammal abundance that are within 10 percent of the mean, 80 percent of the time will be determined during the first year of the study. Sampling will be conducted during the spring and fall (small mammal populations are typically lowest in spring and highest in fall).

An index of abaundance (number captured per 100 trap days) will be calculated from live-trapping data (for each sampling area). Data collected before the Modular Development Phase begins will be compared with that collected in subsequent years. Statistical tests will include F-tests, an analysis of variance, and regression analysis where appropriate (Seber, 1973).

Both live-trapping and pit-trapping data will be used to describe the species composition of small mammals in the areas sampled. These data will not be treated statistically.

2. Parameter 2 - Avifauna

a. Objectives and Rationale - Many species of birds were observed on Tract C-a during baseline studies. Bird groups present in

the RBOSP study area include waterfowl, shorebirds, raptors, upland gamebirds and songbirds. Tract C-a development is not likely to have significant adverse effects on any regional avifauna populations. Habitat enhancement and revegetation programs proposed by RBOSP will increase the amount of food and cover available for certain species of birds. Songbirds, especially those that breed on Tract C-a, are most likely to be affected.

The objective of avifauna studies during the monitoring program is to evaluate the response of breeding songbirds to the revegetation programs proposed by RBOSP.

b. Hypothesis

H_0: Breeding songbird densities are not significantly changed by revegetation.

c. Methods - The breeding bird mapping technique will be used. Each study unit will be divided into one ha subunits (2.47 acres). An observer will search each subunit and record species, location, and breeding activity (e.g., territorial defense, singing) of avifauna observed. The location and contents of nests observed will also be noted. Replicate samples of each subunit will be obtained. Sampling intensity (number of subunits and replicates) will be determined during the first year (see Subsection d).

Breeding bird mapping studies will be conducted during the peak songbird breeding period (late May-early June). A map showing territories and nest locations will be prepared for each subunit. Additional information concerning avifauna in the RBOSP study area will be collected, by general observation, during the spring, summer, and winter (gamebirds and raptors will receive special emphasis).

Avifauna study units will be established in areas to be modified and in control areas (control areas will contain habitat similar to that to be modified). Breeding bird mapping (Graul, 1976; Hall, 1964; Robbins,

1970) will be conducted in control and modified areas, before and during development activities. Study units will be 12 or 42 ha (30 or 105 acres) depending on the openness of the habitat type being sampled. Data collected during the first year will be used to determine the number of subunits and replication of counts on subunits required to estimate population densities of breeding birds on the study unit within 20 percent of the mean, 80 percent of the time.

d. Experimental Design and Data Analysis - The numbers of breeding birds found in each subunit will be used to calculate the density of breeding songbirds in each study unit. Statistical comparisons of density estimates for control and modified areas will be be performed (regression analysis and an F-test in conjunction with analysis of variance (Seber, 1973; Overton, 1971). Territory size and reproductive effort for each species in each study unit will be assessed qualitatively (from maps and field data). Lists of birds observed during qualitative habitat searches will be prepared.

D. Summary - After the initial 5 years of revegetation monitoring have been completed, RBOSP, in cooperation with AOSO, will evaluate the success of the revegetated areas to determine the necessity for additional monitoring or revegetation efforts. If the conditions of the lease have been successfully met, monitoring will be reduced. Forage and browse productivity and utilization, and soil chemistry will be monitored at 5-year intervals. When the AOSO can be assured that no potential impacts (e.g., trace metal toxicity) will occur and that the revegetated areas are stable, monitoring of that particular revegetated "unit" will be suspended. Aerial photographs taken at 5-year intervals during the terrestrial monitoring program (Section 8, Chapter 4) will provide continuing information regarding the general status of each revegetated area.

The combination of the revegetation, soils, and faunal monitoring programs for the revegetated areas will provide data to critically evaluate

the success of the revegetation program and to assess selected interrelationships between vegetation and animal components of revegetated areas. The data collected during the monitoring program will be used to determine whether disturbed vegetation was restored to a condition equal to or better than those existing prior to disturbance.

CHAPTER 8
SUBSIDENCE

A discussion of potential subsidence and means of mitigating and monitoring this impact is discussed in Section 6, Chapter 13 "Subsidence Control".

CHAPTER 9
NOISE

Potential impacts from noise, and suggested mitigation and monitoring plans are discussed in Section 6, Chapter 4 "Noise Control".

SECTION 8

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